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(54) **AEROSOL PROVISION DEVICE**

AEROSOLBEREITSTELLUNGSVORRICHTUNG

DISPOSITIF DE FOURNITURE D'AÉROSOL

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Description

Technical Field

[0001] The present invention relates to an aerosol provision device and an aerosol provision system.

Background

[0002] Smoking articles such as cigarettes, cigars and the like burn tobacco during use to create tobacco smoke. Attempts have been made to provide alternatives to these articles that burn tobacco by creating products that release compounds without burning. Examples of such products are heating devices which release compounds by heating, but not burning, the material. The material may be for example tobacco or other non-tobacco products, which may or may not contain nicotine. EP3229620A1, WO2014/0667730A1, CN104770884A, and WO2018/001910A1 disclose devices of the prior art.

Summary

[0003] In a first aspect of the invention, there is provided an aerosol provision device according to claim 1.

[0004] According to another aspect of the invention, there is provided an aerosol provision system comprising:

an aerosol provision device according to the first aspect; and

an article comprising aerosol generating material.

[0005] Various optional embodiments are provided by the dependent claims.

[0006] Further features and advantages of the invention will become apparent from the following description of preferred embodiments of the invention, given by way of example only, which is made with reference to the accompanying drawings.

Brief Description of the Drawings

[0007]

Figure 1 shows a front view of an example of an aerosol generating device;

Figure 2 shows a front view of the aerosol generating device of Figure 1 with an outer cover removed;

Figure 3 shows a cross-sectional view of the aerosol generating device of Figure 1;

Figure 4 shows an exploded view of the aerosol generating device of Figure 2;

Figure 5A shows a cross-sectional view of a heating assembly within an aerosol generating device;

Figure 5B shows a close-up view of a portion of the heating assembly of Figure 5A;

Figure 6 shows a schematic representation of an

example induction heating circuit for the aerosol generating device of Figures 1 to 5B;

Figure 7A shows a schematic representation of a current through an inductor of the example induction heating circuit of Figure 6;

Figure 7B shows a schematic representation of a voltage across a current sense resistor of the example induction heating circuit of Figure 6;

Figure 8 shows a schematic representation of a voltage across a switching arrangement of the circuit of Figure 6;

Figure 9 shows another schematic representation of the example induction heating circuit for the device of Figures 1 to 5B;

Figures 10 to 13 show various parts of an example control arrangement for the example induction heating circuit represented by previous figures;

Figure 14 shows a flow chart representation of an example method of controlling aspects of an example induction heating circuit;

Figure 15 shows a flow chart representation of another example method of controlling aspects of an example induction heating circuit; and

Figure 16 shows a schematic representation of a temperature of an inductor and a target power to be supplied to the inductor during operation of an example induction heating circuit.

Detailed Description

[0008] As used herein, the term "aerosol generating material" includes materials that provide volatilised components upon heating, typically in the form of an aerosol. Aerosol generating material includes any tobacco-containing material and may, for example, include one or more of tobacco, tobacco derivatives, expanded tobacco, reconstituted tobacco or tobacco substitutes. Aerosol generating material also may include other, non-tobacco, products, which, depending on the product, may or may not contain nicotine. Aerosol generating material may for example be in the form of a solid, a liquid, a gel, a wax or the like. Aerosol generating material may for example also be a combination or a blend of materials. Aerosol generating material may also be known as "smokable material".

[0009] Apparatus is known that heats aerosol generating material to volatilise at least one component of the aerosol generating material, typically to form an aerosol which can be inhaled, without burning or combusting the aerosol generating material. Such apparatus is sometimes described as an "aerosol generating device", an "aerosol provision device", a "heat-not-burn device", a "tobacco heating product device" or a "tobacco heating device" or similar. Similarly, there are also so-called e-cigarette devices, which typically vaporise an aerosol generating material in the form of a liquid, which may or may not contain nicotine. The aerosol generating material may be in the form of or be provided as part of

a rod, cartridge or cassette or the like which can be inserted into the apparatus. A heater for heating and volatilising the aerosol generating material may be provided as a "permanent" part of the apparatus.

[0010] An aerosol provision device can receive an article comprising aerosol generating material for heating. An "article" in this context is a component that includes or contains in use the aerosol generating material, which is heated to volatilise the aerosol generating material, and optionally other components in use. A user may insert the article into the aerosol provision device before it is heated to produce an aerosol, which the user subsequently inhales. The article may be, for example, of a predetermined or specific size that is configured to be placed within a heating chamber of the device which is sized to receive the article.

[0011] The present disclosure describes an aerosol provision device comprising a plurality of electrical components and a heating assembly comprising at least one heater component for heating aerosol generating material. The heater assembly uses inductive heating. The heating assembly comprises at least one coil. The coil is an inductor coil. The heater component is a susceptor, and the coil can heat the susceptor which in turn heats the aerosol generating material.

[0012] The device further comprises a battery to power the plurality of electrical components and the heating assembly. In use, the power consumption of the plurality of electrical components is less than about 0.25W.

[0013] The device therefore comprises a heating assembly configured to heat aerosol generating material, and a plurality of other electrical components. The plurality of electrical components comprise a controller, such as a microprocessor, and a visual indicator, comprising a plurality of LEDs. The plurality of electrical components do not include the heater assembly, such as the heater component and coil(s).

[0014] The power consumption of the plurality of electrical components is preferably less than about 0.1W. It has been found that keeping the power consumption of the electrical components below 0.1W can reduce the surface temperature of the device, as well as contributing to overall energy efficiency. For example, it may be desirable to maintain the surface temperature of the device below about 48°C or below about 43°C. The electrical components may have a larger influence on surface temperature than expected because they may be located nearer to the surface than the heating components and be less well insulated. By using energy efficient components, the surface temperature of the device can be reduced. In addition, when the electrical components consume less than about 0.1W, the device can be used for a longer period of time before the battery needs to be recharged.

[0015] The battery may be a DC power supply. The battery may be a module of batteries, or a battery assembly. The battery may be a 3-4V battery.

[0016] The power consumption of the plurality of elec-

trical components may be less than about 0.05W or less than about 0.04W, or less than about 0.01W.

[0017] In one example, the plurality of electrical components comprises a controller, and when the controller is active, the power consumption of the controller is between about 10mW and about 20mW, and when the controller is inactive, the power consumption of the plurality of electrical components is less than about 0.5mW.

[0018] The plurality of electrical components comprises a plurality of LEDs and each LED has a power consumption of less than about 0.01W at maximum brightness or intensity. In one example, there are four LEDs, and the power consumption of the four LEDs is less than about 0.04W at maximum brightness. For example, the power consumption of the four LEDs may be about 0.03W.

[0019] Accordingly, the plurality of electrical components may comprise four LEDs and a controller, and the power consumption of the electrical components is less than about 0.5mW when the controller is inactive, and the LEDs are switched off. The power consumption of the electrical components is less than about 0.05W when the controller is active, and the LEDs are switched on. For example, the power consumption of the electrical components may be between about 0.03W and about 0.05W when the controller is active, and the LEDs are switched on.

[0020] During a heating session, the heating assembly may consume between about 15W and about 25W. For example, in use, the power consumption of the heater assembly is between about 15W and about 25W. Preferably the power consumption of the heater assembly is between about 20W and about 25W, such as between about 20W and about 23W.

[0021] In some examples, the plurality of electrical components include a WiFi interface and/or a Bluetooth interface and/or an NFC interface.

[0022] In some examples, the power consumption of the plurality of electrical components is less than about 1% of the power consumption of the heating assembly. In another example, the power consumption of the plurality of electrical components is less than about 0.5% of the power consumption of the heating assembly. Preferably, the power consumption of the electrical components is less than about 0.2% of the power consumption of the heating assembly. For example, the power consumption of the plurality of electrical components may be about 0.05W and the power consumption of the heater assembly may be about 20W.

[0023] The battery may have a battery capacity of between about 30000J and 35000J.

[0024] The heater assembly may be configured to operate for a period of about 3 minutes to about 5 minutes, and may be configured to consume between about 1000J and about 1400J during the period. The battery may therefore be configured to power the heater assembly for between about 20 and about 35 periods. Each period may be known as a heating session. During the

period the one or more inductor coils may be intermittently operated.

[0025] Preferably, the device is a tobacco heating device, also known as a heat-not-burn device.

[0026] As briefly mentioned above, the coil(s) is/are configured to, in use, cause heating of at least one electrically-conductive heating component/element (also known as a heater component/element), so that heat energy is conductible from the at least one electrically-conductive heating component to aerosol generating material to thereby cause heating of the aerosol generating material.

[0027] The coil(s) is/are configured to generate, in use, a varying magnetic field for penetrating at least one heating component/element, to thereby cause induction heating and/or magnetic hysteresis heating of the at least one heating component. In such an arrangement, the or each heating component is termed a "susceptor". A coil that is configured to generate, in use, a varying magnetic field for penetrating at least one electrically-conductive heating component, to thereby cause induction heating of the at least one electrically-conductive heating component, may be termed an "induction coil" or "inductor coil".

[0028] The device may include the heating component(s), for example electrically-conductive heating component(s), and the heating component(s) may be suitably located or locatable relative to the coil(s) to enable such heating of the heating component(s). The heating component(s) may be in a fixed position relative to the coil(s). Alternatively, the at least one heating component, for example at least one electrically-conductive heating component, may be included in an article for insertion into a heating zone of the device, wherein the article also comprises the aerosol generating material and is removable from the heating zone after use. Alternatively, both the device and such an article may comprise at least one respective heating component, for example at least one electrically-conductive heating component, and the coil(s) may be to cause heating of the heating component(s) of each of the device and the article when the article is in the heating zone.

[0029] In some examples, the coil(s) is/are helical. In some examples, the coil(s) encircles at least a part of a heating zone of the device that is configured to receive aerosol generating material. In some examples, the coil(s) is/are helical coil(s) that encircles at least a part of the heating zone. The heating zone may be a receptacle, shaped to receive the aerosol generating material.

[0030] In some examples, the device comprises an electrically-conductive heating component that at least partially surrounds the heating zone, and the coil(s) is/are helical coil(s) that encircles at least a part of the electrically-conductive heating component. In some examples, the electrically-conductive heating component is tubular. In some examples, the coil is an inductor coil.

[0031] Figure 1 shows an example of an aerosol provision device 100 for generating aerosol from an aerosol

generating medium/material. In broad outline, the device 100 may be used to heat a replaceable article 110 comprising the aerosol generating medium, to generate an aerosol or other inhalable medium which is inhaled by a user of the device 100.

[0032] The device 100 comprises a housing 102 (in the form of an outer cover) which surrounds and houses various components of the device 100. The device 100 has an opening 104 in one end, through which the article 110 may be inserted for heating by a heating assembly. In use, the article 110 may be fully or partially inserted into the heating assembly where it may be heated by one or more components of the heater assembly.

[0033] The device 100 of this example comprises a first end member 106 which comprises a lid 108 which is moveable relative to the first end member 106 to close the opening 104 when no article 110 is in place. In Figure 1, the lid 108 is shown in an open configuration, however the cap 108 may move into a closed configuration. For example, a user may cause the lid 108 to slide in the direction of arrow "A".

[0034] The device 100 may also include a user-operable control element 112, such as a button or switch, which operates the device 100 when pressed. For example, a user may turn on the device 100 by operating the switch 112.

[0035] The device 100 may also comprise an electrical component, such as a socket/port 114, which can receive a cable to charge a battery of the device 100. For example, the socket 114 may be a charging port, such as a USB charging port. In some examples the socket 114 may be used additionally or alternatively to transfer data between the device 100 and another device, such as a computing device.

[0036] Figure 2 depicts the device 100 of Figure 1 with the outer cover 102 removed. The device 100 defines a longitudinal axis 134.

[0037] As shown in Figure 2, the first end member 106 is arranged at one end of the device 100 and a second end member 116 is arranged at an opposite end of the device 100. The first and second end members 106, 116 together at least partially define end surfaces of the device 100. For example, the bottom surface of the second end member 116 at least partially defines a bottom surface of the device 100. Edges of the outer cover 102 may also define a portion of the end surfaces. In this example, the lid 108 also defines a portion of a top surface of the device 100. Figure 2 also shows a second printed circuit board 138 associated within the control element 112.

[0038] The end of the device closest to the opening 104 may be known as the proximal end (or mouth end) of the device 100 because, in use, it is closest to the mouth of the user. In use, a user inserts an article 110 into the opening 104, operates the user control 112 to begin heating the aerosol generating material and draws on the aerosol generated in the device. This causes the aerosol to flow through the device 100 along a flow path

towards the proximal end of the device 100.

[0039] The other end of the device furthest away from the opening 104 may be known as the distal end of the device 100 because, in use, it is the end furthest away from the mouth of the user. As a user draws on the aerosol generated in the device, the aerosol flows away from the distal end of the device 100.

[0040] The device 100 further comprises a power source 118. The power source 118 may be, for example, a battery, such as a rechargeable battery or a non-rechargeable battery. Examples of suitable batteries include, for example, a lithium battery (such as a lithium-ion battery), a nickel battery (such as a nickel-cadmium battery), and an alkaline battery. The battery is electrically coupled to the heating assembly to supply electrical power when required and under control of a controller (not shown) to heat the aerosol generating material. In this example, the battery is connected to a central support 120 which holds the battery 118 in place. The power source 118 may be a DC voltage source 118.

[0041] The device further comprises at least one electronics module 122. The electronics module 122 may comprise, for example, a printed circuit board (PCB). The PCB 122 may support at least one controller, such as a processor, and memory. The PCB 122 may also comprise one or more electrical tracks to electrically connect together various electronic components of the device 100. For example, the battery terminals may be electrically connected to the PCB 122 so that power can be distributed throughout the device 100. The socket 114 may also be electrically coupled to the battery via the electrical tracks.

[0042] In the example device 100, the heating assembly is an inductive heating assembly and comprises various components to heat the aerosol generating material of the article 110 via an inductive heating process. Induction heating is a process of heating an electrically conducting object (such as a susceptor) by electromagnetic induction. An induction heating assembly may comprise an inductive element, for example, one or more inductor coils, and a device for passing a varying electric current, such as an alternating electric current, through the inductive element. The varying electric current in the inductive element produces a varying magnetic field. The varying magnetic field penetrates a susceptor suitably positioned with respect to the inductive element, and generates eddy currents inside the susceptor. The susceptor has electrical resistance to the eddy currents, and hence the flow of the eddy currents against this resistance causes the susceptor to be heated by Joule heating. In cases where the susceptor comprises ferromagnetic material such as iron, nickel or cobalt, heat may also be generated by magnetic hysteresis losses in the susceptor, i.e. by the varying orientation of magnetic dipoles in the magnetic material as a result of their alignment with the varying magnetic field. In inductive heating, as compared to heating by conduction for example, heat is generated inside the susceptor, allowing for rapid heat-

ing. Further, there need not be any physical contact between the inductive heater and the susceptor, allowing for enhanced freedom in construction and application.

[0043] The induction heating assembly of the example device 100 comprises a susceptor arrangement 132 (herein referred to as "a susceptor"), a first inductor coil 124 and a second inductor coil 126. The first and second inductor coils 124, 126 are made from an electrically conducting material. In this example, the first and second inductor coils 124, 126 are made from Litz wire/cable which is wound in a helical fashion to provide helical inductor coils 124, 126. Litz wire comprises a plurality of individual wires which are individually insulated and are twisted together to form a single wire. Litz wires are designed to reduce the skin effect losses in a conductor. In the example device 100, the first and second inductor coils 124, 126 are made from copper Litz wire which has a substantially circular cross section. In other examples the Litz wire can have other shape cross sections, such as rectangular.

[0044] The first inductor coil 124 is configured to generate a first varying magnetic field for heating a first section of the susceptor 132 and the second inductor coil 126 is configured to generate a second varying magnetic field for heating a second section of the susceptor 132. Herein, the first section of the susceptor 132 is referred to as the first susceptor zone 132a and the second section of the susceptor 132 is referred to as the second susceptor zone 132b. In this example, the first inductor coil 124 is adjacent to the second inductor coil 126 in a direction along the longitudinal axis 134 of the device 100 (that is, the first and second inductor coils 124, 126 do not overlap). In this example the susceptor arrangement 132 comprises a single susceptor comprising two zones, however in other examples the susceptor arrangement 132 may comprise two or more separate susceptors. Ends 130 of the first and second inductor coils 124, 126 are connected to the PCB 122.

[0045] It will be appreciated that the first and second inductor coils 124, 126, in some examples, may have at least one characteristic different from each other. For example, the first inductor coil 124 may have at least one characteristic different from the second inductor coil 126. More specifically, in one example, the first inductor coil 124 may have a different value of inductance than the second inductor coil 126. In Figure 2, the first and second inductor coils 124, 126 are of different lengths such that the first inductor coil 124 is wound over a smaller section of the susceptor 132 than the second inductor coil 126. Thus, the first inductor coil 124 may comprise a different number of turns than the second inductor coil 126 (assuming that the spacing between individual turns is substantially the same). In yet another example, the first inductor coil 124 may be made from a different material to the second inductor coil 126. In some examples, the first and second inductor coils 124, 126 may be substantially identical.

[0046] In this example, the inductor coils 124 126 are

wound in the same direction as one another. That is, both the first inductor coil 124, and the second inductor coil 126 are left-hand helices. In another example, both inductor coils 124, 126 may be right-hand helices. In yet another example (not shown), the first inductor coil 124 and the second inductor coil 126 are wound in opposite directions. This can be useful when the inductor coils are active at different times. For example, initially, the first inductor coil 124 may be operating to heat a first section of the article 110, and at a later time, the second inductor coil 126 may be operating to heat a second section of the article 110. Winding the coils in opposite directions helps reduce the current induced in the inactive coil when used in conjunction with a particular type of control circuit. In one example where the coils 124, 126 are wound in different directions (not shown) the first inductor coil 124 may be a right-hand helix and the second inductor coil 126 may be a left-hand helix. In another such embodiment, the first inductor coil 124 may be a left-hand helix and the second inductor coil 126 may be a right-hand helix.

[0047] The susceptor 132 of this example is hollow and therefore defines a receptacle within which aerosol generating material is received. For example, the article 110 can be inserted into the susceptor 132. In this example the susceptor 132 is tubular, with a circular cross section.

[0048] The device 100 of Figure 2 further comprises an insulating member 128 which may be generally tubular and at least partially surround the susceptor 132. The insulating member 128 may be constructed from any insulating material, such as a plastics material for example. In this particular example, the insulating member is constructed from polyether ether ketone (PEEK). The insulating member 128 may help insulate the various components of the device 100 from the heat generated in the susceptor 132.

[0049] The insulating member 128 can also fully or partially support the first and second inductor coils 124, 126. For example, as shown in Figure 2, the first and second inductor coils 124, 126 are positioned around the insulating member 128 and are in contact with a radially outward surface of the insulating member 128. In some examples the insulating member 128 does not abut the first and second inductor coils 124, 126. For example, a small gap may be present between the outer surface of the insulating member 128 and the inner surface of the first and second inductor coils 124, 126.

[0050] In a specific example, the susceptor 132, the insulating member 128, and the first and second inductor coils 124, 126 are coaxial around a central longitudinal axis of the susceptor 132.

[0051] Figure 3 shows a side view of device 100 in partial cross-section. The outer cover 102 is again not present in this example. The circular cross-sectional shape of the first and second inductor coils 124, 126 is more clearly visible in Figure 3.

[0052] The device 100 further comprises a support 136 which engages one end of the susceptor 132 to hold the

susceptor 132 in place. The support 136 is connected to the second end member 116.

[0053] The device 100 further comprises a second lid/cap 140 and a spring 142, arranged towards the distal end of the device 100. The spring 142 allows the second lid 140 to be opened, to provide access to the susceptor 132. A user may, for example, open the second lid 140 to clean the susceptor 132 and/or the support 136.

[0054] The device 100 further comprises an expansion chamber 144 which extends away from a proximal end of the susceptor 132 towards the opening 104 of the device. Located at least partially within the expansion chamber 144 is a retention clip 146 to abut and hold the article 110 when received within the device 100. The expansion chamber 144 is connected to the end member 106.

[0055] Figure 4 is an exploded view of the device 100 of Figure 1, with the outer cover 102 again omitted.

[0056] Figure 5A depicts a cross section of a portion of the device 100 of Figure 1. Figure 5B depicts a close-up of a region of Figure 5A. Figures 5A and 5B show the article 110 received within the susceptor 132, where the article 110 is dimensioned so that the outer surface of the article 110 abuts the inner surface of the susceptor 132. This ensures that the heating is most efficient. The article 110 of this example comprises aerosol generating material 110a. The aerosol generating material 110a is positioned within the susceptor 132. The article 110 may also comprise other components such as a filter, wrapping materials and/or a cooling structure.

[0057] Figure 5B shows that the outer surface of the susceptor 132 is spaced apart from the inner surface of the inductor coils 124, 126 by a distance 150, measured in a direction perpendicular to a longitudinal axis 158 of the susceptor 132. In one particular example, the distance 150 is about 3mm to 4mm, about 3mm to 3.5mm, or about 3.25mm.

[0058] Figure 5B further shows that the outer surface of the insulating member 128 is spaced apart from the inner surface of the inductor coils 124, 126 by a distance 152, measured in a direction perpendicular to a longitudinal axis 158 of the susceptor 132. In one particular example, the distance 152 is about 0.05mm. In another example, the distance 152 is substantially 0mm, such that the inductor coils 124, 126 abut and touch the insulating member 128.

[0059] In one example, the susceptor 132 has a wall thickness 154 of about 0.025mm to 1mm, or about 0.05mm.

[0060] In one example, the susceptor 132 has a length of about 40mm to 60mm, about 40mm to 45mm, or about 44.5mm.

[0061] In one example, the insulating member 128 has a wall thickness 156 of about 0.25mm to 2mm, 0.25mm to 1mm, or about 0.5mm.

[0062] As has been described above, the heating assembly of the example device 100 is an inductive heating assembly comprising various components to heat the aerosol generating material of article 110 via an induction

heating process. In particular, the first inductor coil 124 and the second inductor coil 126 are used to heat respective first 132a and second 132b zones of the susceptor 132 in order to heat the aerosol generating material and generate an aerosol. Below, with reference to Figures 6 to 12, the operation of the device 100 in using the first and second inductor coils 124, 126 to inductively heat the susceptor arrangement 132 will be described in detail.

[0063] The inductive heating assembly of the device 100 comprises an LC circuit. An LC circuit, has an inductance L provided by an induction element, and a capacitance C provided by a capacitor. In the device 100, the inductance L is provided by the first and second inductor coils 124, 126 and the capacitance C is provided by a plurality of capacitors as will be discussed below. An induction heater circuit comprising an inductance L and a capacitance C may in some cases be represented as an RLC circuit, comprising a resistance R provided by a resistor. In some cases, resistance is provided by the ohmic resistance of parts of the circuit connecting the inductor and the capacitor, and hence the circuit need not necessarily include a resistor as such. Such circuits may exhibit electrical resonance, which occurs at a particular resonant frequency when the imaginary parts of impedances or admittances of circuit elements cancel each other.

[0064] One example of an LC circuit is a series circuit where the inductor and capacitor are connected in series. Another example of an LC circuit is a parallel LC circuit where the inductor and capacitor are connected in parallel. Resonance occurs in an LC circuit because the collapsing magnetic field of the inductor generates an electric current in its windings that charges the capacitor, while the discharging capacitor provides an electric current that builds the magnetic field in the inductor. When a parallel LC circuit is driven at the resonant frequency, the dynamic impedance of the circuit is at maximum (as the reactance of the inductor equals the reactance of the capacitor), and circuit current is at a minimum. However, for a parallel LC circuit, the parallel inductor and capacitor loop acts as a current multiplier (effectively multiplying the current within the loop and thus the current passing through the inductor). Allowing the RLC or LC circuit to operate at the resonant frequency for at least some of the time while the circuit is in operation to heat the susceptor may therefore provide for effective and/or efficient inductive heating by providing for the greatest value of the magnetic field penetrating the susceptor.

[0065] The LC circuit used by the device 100 to heat the susceptor 132 may make use of one or more transistors acting as a switching arrangement as will be described below. A transistor is a semiconductor device for switching electronic signals. A transistor typically comprises at least three terminals for connection to an electronic circuit. A field effect transistor (FET) is a transistor in which the effect of an applied electric field may be used to vary the effective conductance of the transistor. The field

effect transistor may comprise a body, a source terminal S, a drain terminal D, and a gate terminal G. The field effect transistor comprises an active channel comprising a semiconductor through which charge carriers, electrons or holes, may flow between the source S and the drain D. The conductivity of the channel, i.e. the conductivity between the drain D and the source S terminals, is a function of the potential difference between the gate G and source S terminals, for example generated by a potential applied to the gate terminal G. In enhancement mode FETs, the FET may be OFF (i.e. substantially prevent current from passing therethrough) when there is substantially zero gate G to source S voltage, and may be turned ON (i.e. substantially allow current to pass therethrough) when there is a substantially non-zero gate G - source S voltage.

[0066] One type of transistor which may be used in circuitry of the device 100 is an n-channel (or n-type) field effect transistor (n-FET). An n-FET is a field effect transistor whose channel comprises an n-type semiconductor, where electrons are the majority carriers and holes are the minority carriers. For example, n-type semiconductors may comprise an intrinsic semiconductor (such as silicon for example) doped with donor impurities (such as phosphorus for example). In n-channel FETs, the drain terminal D is placed at a higher potential than the source terminal S (i.e. there is a positive drain-source voltage, or in other words a negative source-drain voltage). In order to turn an n-channel FET "on" (i.e. to allow current to pass therethrough), a switching potential is applied to the gate terminal G that is higher than the potential at the source terminal S.

[0067] Another type of transistor which may be used in the device 100 is a p-channel (or p-type) field effect transistor (p-FET). A p-FET is a field effect transistor whose channel comprises a p-type semiconductor, where holes are the majority carriers and electrons are the minority carriers. For example, p-type semiconductors may comprise an intrinsic semiconductor (such as silicon for example) doped with acceptor impurities (such as boron for example). In p-channel FETs, the source terminal S is placed at a higher potential than the drain terminal D (i.e. there is a negative drain-source voltage, or in other words a positive source-drain voltage). In order to turn a p-channel FET "on" (i.e. to allow current to pass therethrough), a switching potential is applied to the gate terminal G that is lower than the potential at the source terminal S (and which may for example be higher than the potential at the drain terminal D).

[0068] In examples, one or more of the FETs used in the device 100 may be a metal-oxide-semiconductor field effect transistor (MOSFET). A MOSFET is a field effect transistor whose gate terminal G is electrically insulated from the semiconductor channel by an insulating layer. In some examples, the gate terminal G may be metal, and the insulating layer may be an oxide (such as silicon dioxide for example), hence "metal-oxide-semiconductor". However, in other examples, the gate may be made

from other materials than metal, such as polysilicon, and/or the insulating layer may be made from other materials than oxide, such as other dielectric materials. Such devices are nonetheless typically referred to as metal-oxide-semiconductor field effect transistors (MOSFETs), and it is to be understood that as used herein the term metal-oxide-semiconductor field effect transistors or MOSFETs is to be interpreted as including such devices.

[0069] A MOSFET may be an n-channel (or n-type) MOSFET where the semiconductor is n-type. The n-channel MOSFET (n-MOSFET) may be operated in the same way as described above for the n-channel FET. As another example, a MOSFET may be a p-channel (or p-type) MOSFET, where the semiconductor is p-type. The p-channel MOSFET (p-MOSFET) may be operated in the same way as described above for the p-channel FET. An n-MOSFET typically has a lower source-drain resistance than that of a p-MOSFET. Hence in an "on" state (i.e. where current is passing therethrough), n-MOSFETs generate less heat as compared to p-MOSFETs, and hence may waste less energy in operation than p-MOSFETs. Further, n-MOSFETs typically have shorter switching times (i.e. a characteristic response time from changing the switching potential provided to the gate terminal G to the MOSFET changing whether or not current passes therethrough) as compared to p-MOSFETs. This can allow for higher switching rates and improved switching control.

[0070] Now with reference to Figure 6, circuitry for induction heating by the device 100 will be described. Figure 6 shows a simplified schematic representation of a part of an induction heating circuit 600 of the aerosol generating device 100. Figure 6 shows a part of the induction heating circuit 600 which comprises the first inductor coil 124 for heating the first susceptor zone 132a when a varying current flows through the first inductor coil 124. The first susceptor zone 132a is represented in Figure 6 as having an inductive element and a resistive element to represent how the susceptor 132 couples inductively with the first inductor 124 and is heated through the generation of eddy currents. It will be noted that the device 100 additionally comprises the second inductor coil 126, which is not shown in Figure 6. The second inductor coil 126 is also part of the induction heating circuit 600 and is controlled to heat the second susceptor zone 132b as will be described below. However, for the sake of clarity, the circuit 600 will first be described with reference to those features shown in Figure 6.

[0071] The circuit 600 comprises a first resonator section 601, the DC voltage supply 118 for supplying a DC voltage to the first resonator section 601, as well as a control arrangement for controlling the circuit 600. The first resonator section 601 comprises the first inductor 124 and a switching arrangement comprising a first FET 608, and the control arrangement is configured to switch the FET 608 between a first state and a second state in

response to voltage conditions detected in the circuit 600, as will be described in more detail below, to operate the first inductor 124. The circuit 600, with the exception of the susceptor 132, is arranged on the PCB 122 of the device 100, with the inductor coil 124 being connected to the PCB 122 at a first end 130a and a second end 130b.

[0072] The first resonator section 601 comprises a first capacitor 606, and a second capacitor 610, both arranged in parallel with the first inductor 124 such that when the first resonator section 601 is allowed to resonate an alternating current flows between the first capacitor 606 and the second capacitor 610 and through the inductor 124. As mentioned above, the first FET 608, in this example an n-channel MOSFET, is arranged to operate as a switching arrangement in the first resonator section 601.

[0073] It should be noted that in other examples, the resonator section 601 may comprise only one capacitor, for example in the position of the first capacitor 606, or at the position of the second capacitor 610. In other examples, the resonator section 601 may comprise any other number of capacitors, such as three or more capacitors. For example, either or both of the first capacitor 606 and the second capacitor 610 may be replaced by two or more capacitors arranged in parallel with one another. As will be well understood, the resonator section 601 has a resonant frequency which is dependent on the inductance L and the capacitance C of the resonator section 601. The number, type and arrangement of capacitors in the resonating section 601 may be selected based on considerations of the power levels to be used in the circuit 600 and the desired frequency of operation of the circuit 600. For example, it will be understood that individual capacitors and an arrangement of said capacitors can be considered to have an equivalent series resistance (ESR) as well as a limit on the ability of said capacitors to handle current. Such features may be taken into account when determining an arrangement of capacitors to provide the capacitance in the resonator section 601. For example, depending on desired power levels and frequency of operation, there may be an advantage to providing a plurality of capacitors in parallel, to provide higher capacitance or lower ESR. In this example, the first and second capacitors 606, 610 are both ceramic COG capacitors each having a capacitance of around 100nF. In other examples, other types of capacitor and/or capacitors with other capacitance values, e.g. capacitors with unequal capacitance values, may be used, according to the considerations outlined in this paragraph.

[0074] The first resonator section 601 is supplied a DC voltage by the DC voltage supply 118, which is, for example, as described above, a voltage supplied by a battery. As shown in Figure 6, the DC voltage supply 118 comprises a positive terminal 118a and a negative terminal 118b. In one example, the DC voltage supply 118 supplies a DC voltage of around 4.2V to the first resonator section 601. In other examples, the DC voltage supply 118 may supply a voltage of 2 to 10V, or around 3 to 5V, for

example.

[0075] A controller 1001 is configured to control operation of the circuit 600. The controller 1001 may comprise a micro-controller, e.g. a micro-processing unit (MPU), comprising a plurality of inputs and outputs. In one example, the controller 1001 is an STM32L051C8T6 model MPU. In some examples, the DC voltage supply 118 provided to the circuit 600 is provided by an output from the controller 1001 which itself receives power from a battery or other power source.

[0076] The positive terminal 118a of the DC voltage source 118 is electrically connected to a first node 600A. In an example, the DC voltage source 118 is connected to the node 600A via the controller 1001 which receives power from the DC voltage source 118 and supplies the voltage supplied by the DC voltage source to components of the device, including the circuit 600. The first node 600A is electrically connected to a first end 606a of the first capacitor 606 and to the first end 130a of the first inductor 124. The second end 130b of the first inductor 124 is electrically connected to a second node 600B, which in Figure 6 is represented at two electrically equivalent points in the circuit diagram. The second node 600B is electrically connected to a drain terminal 608D of the FET 608. In this example, the second node 600B is also electrically connected to a first end 610a of the second capacitor 610. Continuing around the circuit, the source terminal 608S of the first FET 608 is electrically connected to a third node 600C. The third node 600C is electrically connected to ground 616, and in this example to a second end 610b of the second capacitor 610. The third node 600C is electrically connected via a current sense resistor 615 to a fourth node 600D, and the fourth node 600D is electrically connected to the negative terminal 118b of the DC voltage source 118, which, as with the positive terminal, in an example is supplied via the controller 1001.

[0077] It should be noted that in examples where the second capacitor 610 is not present, the third node 600C may have only three electrical connections: to the first FET source terminal 608S, to ground 616 and to the current sense resistor 615.

[0078] As mentioned above, the first FET 608 acts a switching arrangement in the first resonator section 601. The first FET 608 is configurable between a first state, i.e. an 'ON' state and a second state, i.e. an 'OFF' state. As will be well understood by those skilled in the art when an n-channel FET is in an OFF state (i.e. when the appropriate control voltage is not applied to its gate) it effectively acts as a diode. In Figure 6, the diode functionality that the first FET 608 exhibits when in its OFF state is represented by a first diode 608a. That is, when the FET 608 is in the OFF state the first diode 608a acts to largely prevent current flowing from the drain terminal 608D to the source terminal 608S but allows current to flow from the source terminal 608S to the drain terminal 608D if the diode 608a is appropriately forward biased. An n-channel FET is in an ON state when an appropriate control voltage

is applied to its gate so that a conductive path exists between its drain D and source S. As such, when the first FET 608 is in the ON state, it acts like a closed switch in the first resonator section 601.

[0079] As mentioned above, the circuit 600 may be considered to comprise a first resonator section 601 and an additional control arrangement. The control arrangement comprises a comparator 618, a zero-voltage detector 621, and a flip-flop 622, and is configured to detect voltage conditions within the first resonator section 601 and to control the first FET 608 in response to the detected voltage conditions. This control of the first FET 608 by the control arrangement will now be described in more detail.

[0080] At the second node 600B there is electrically connected the zero-voltage detector 621, which is configured to detect a voltage condition, i.e. a voltage of at or near 0V with respect to a ground voltage, at a point in the circuit 600 to which the zero-voltage detector 621 is connected. The zero-voltage detector 621 is configured to output a signal to control switching of the state of the FET 608. That is, the zero-voltage detector 621 is configured to output a signal to the flip-flop 622. The flip-flop 622 is an electrical circuit which is configurable between two stable states. The flip-flop 622 is electrically connected to a first gate driver 623 which is configured to provide a voltage to the first FET gate terminal 608G dependent on the state of the flip-flop. That is, the first gate driver 623 is configured to provide an appropriate voltage to the first FET gate terminal 608G to switch the FET 608 to the ON state when the flip-flop is in one state, but is configured not to provide a voltage appropriate for maintaining the FET 608 in the ON state when the flip-flop 622 is in the other state. For example, the first gate driver 623 may be configured to provide an appropriate gate-source voltage to the first FET gate 608G to switch the FET 608 ON when the flip-flop 622 is in a state '1', and the first gate driver 623 may be configured not to provide the gate-source voltage when the flip-flop 622 is in state '0'. The state of the flip-flop means 622 therefore controls whether the first FET 608 is on or off.

[0081] In this example, the zero-voltage detector 621 and the first gate driver 623 of the control arrangement are configured to receive respective signals 1011, 1021 from the controller 1001, by which signals the controller 1001 can initiate and control operation of the circuit 600, as will be discussed in more detail below.

[0082] At the fourth node 600D, there is electrically connected a control voltage line 619. The control voltage line 619 is electrically connected to a fifth node 600E via a resistor 617a and the fifth node 600E is electrically connected to the voltage comparator 618 - hereinafter comparator 618. The fifth node 600E is electrically connected to a positive terminal of the comparator 618. A negative terminal of the comparator 618 is connected to ground 616. In this example, the comparator 618 is configured to output a signal based on a comparison of the voltage at the fifth node 600E to ground voltage. The output signal of

the comparator 618 is sent to the flip-flop 622. A control voltage 1031 is supplied, in this example from the controller 1001, to the control voltage line 619 via a second resistor 617b.

[0083] As mentioned above, the comparator 618 is electrically connected to provide an output to the flip-flop 622. The flip-flop 622 is configured such that an output signal from the comparator 618 can change the state of the flip-flop 622, and thereby cause the first driver 623 to change the state of the first FET 608.

[0084] The functioning of the example circuit 600 will now be described in more detail in the context of the first resonator section 601 being activated by the controller 1001 such that the first inductor coil 124 is operated to heat the first susceptor zone 132a.

[0085] To begin, the first FET 608 is configured in the OFF state, and is thus acting as a diode 608a, preventing current flowing through the inductor 124. The controller 1001 initiates the operation of the circuit 600 to heat the first susceptor zone 132a by causing the FET 608 to switch from the OFF state to the ON state. In this example the controller initiates operation of the circuit 600 by providing a START signal 1011 to the zero-voltage detector 621. The flip-flop 622 is thereby caused to change states and cause the first gate driver 623 to provide a signal to the FET gate terminal 608G to thereby switch the FET to the ON state.

[0086] Once the FET 608 is switched to the ON state, what may be referred to as a self-oscillating heating cycle of the circuit 600 begins. The FET 608, now being in the ON state, acts as a closed switch a DC current to begin flowing from the DC voltage source positive terminal 118a through the first inductor 124 and returning to the DC voltage source negative terminal 118b via the current sense resistor 615. The first inductor 124 opposes this initial increase in current, as is well-known, generating a back emf via Faraday's and Lenz's laws. In the ON state, the voltage between the drain terminal 608D and the source terminal 608S is substantially zero.

[0087] Figure 7A shows a schematic graphical representation of the current flowing through the first inductor 124 against time t starting from when the FET 608 is switched on, at time t_0 . From time t_0 , a DC current begins to build up in the inductor 124 from zero at a rate which is dependent on an inductance $L1$ of the inductor 124 and a DC resistance of the circuit 600. In one example the current sense resistor 615 has a resistance of around $2\text{m}\Omega$, while the inductor 124 has a DC resistance of, 2 to $15\text{m}\Omega$, or 4 to $10\text{m}\Omega$ or in this example around $5.2\text{m}\Omega$. This build-up of current in the inductor corresponds to the inductor 124 storing magnetic energy, and the amount of magnetic energy which can be stored by the inductor 124 is dependent on its inductance $L1$, as will be well understood.

[0088] Figure 7B shows a simplified representation of the voltage across the current sense resistor 615 against time t , again from the time t_0 when the FET 608 is turned on. Shortly after the FET 608 is turned on, a large voltage

develops across the inductor 124, this being the back emf generated by the inductor 124 as the inductor opposes the increase in current. At this time, therefore, the voltage across the current sense resistor 615 as shown in Figure 7B is small, since almost all of the voltage difference provided by the DC supply 118 drops across the inductor 124. Then, as the current through the inductor 124 increases and the back emf of the inductor 124 decays, the voltage across the current sense resistor 615 increases. This is seen as the development of a negative voltage across the current sense resistor 615, as shown in Figure 7B. That is, the voltage across the current sense resistor 615 becomes increasingly negative with the length of time that the FET 608 is on.

[0089] Since the increasingly negative voltage across the current sense resistor 615 corresponds with the increasing current through the inductor 124, the magnitude of the voltage across the current sense resistor 615 is indicative of the current flowing through the inductor 124. While the FET 608 remains on, the current through the inductor 124 and the voltage across the current sense resistor 615 increase substantially linearly towards respective maximum values I_{max} , V_{max} (which are dependent on the DC voltage supplied by DC supply 118 and the DC resistance of the circuit 600) with a time constant dependent on the inductance $L1$ and on the DC resistance of the circuit 600. It should be noted that as the current through the inductor 124 is varying after time t_0 some inductive heating of the susceptor 132 may occur while the DC current through the first inductor 124 builds up.

[0090] The circuit 600 is configured such that the amount of energy which is stored in the first inductor 124 in the time during which the FET 608 is switched on, is determined by the control arrangement and can be controlled by the controller 1001. That is, the controller 1001 controls an amount of DC current (and thus an amount of magnetic energy) allowed to build up in the inductor 124, as will now be described.

[0091] As described above, the control voltage 1031 is applied to the control voltage line 619. In this example, the control voltage 1031 is a positive voltage and the voltage input to the positive terminal of the comparator 618 (i.e. the voltage at the fifth node 600E) at any one time is dependent on the value of control voltage 1031 and the voltage at the fourth node 600D. When the negative voltage across the current sense resistor 615 reaches a particular value, it cancels, at the fifth node 600E, the positive control voltage 1031 and gives a voltage of 0V (i.e. ground voltage) at the fifth node 600E. In this example, the resistor 617a has a resistance of $2\text{m}\Omega$. The resistor 617b represents an effective resistance to the controller 1001 of $70\text{k}\Omega$. The voltage at the fifth node 600E reaches 0V when the negative voltage across the current sense resistor 615 has the same magnitude as the control voltage 1031.

[0092] The comparator 618 is configured to compare the voltage at its positive terminal to the voltage of ground

616, connected to its negative terminal, and output a signal as a result. In one example the comparator is a standard component FAN156, as may be obtained from On-Semiconductor. Accordingly, when the voltage at fifth node 600E reaches 0V, the comparator 618 receives a 0V signal at its positive terminal, and the result of the comparison by the comparator 618 is that the voltage at the positive terminal is equal to the voltage at the negative terminal. The comparator 618 consequently outputs a signal to the flip-flop 622 and causes the FET 608 to be switched off. As such, switching off of the FET 608 is dependent on a voltage condition detected in the circuit 600. Namely, in this example, when the comparator 618 detects by comparison of the voltage across its terminals that a negative voltage across the current sense resistor 615 has reached the same magnitude as the control voltage 1031, which occurs at time t_1 , the FET 608 is switched off. In Figure 7A, the DC current flowing through the inductor 124 at time t_1 when the FET 608 is switched off is labelled I_1 .

[0093] When the FET 608 is turned off, at time t_1 , the FET 608 switches from acting like a closed switch to acting like a diode 608a in the resonator section 601, and for the purposes of supply from the DC supply 118 effectively acting like an open switch. At time t_1 the path of the DC current through the inductor 124 to ground 616 is interrupted by the FET 608. This triggers the current flowing in the first inductor 124 to drop off (this is not shown in Figure 7A), and the inductor 124 opposes this change in current by generating an induced voltage. Accordingly, current begins oscillating back and forth between the inductor 124 and the capacitors 606, 608 at the resonant frequency of the first resonator section 601.

[0094] Similarly, the voltage across the inductor 124 and thereby between the first FET drain 608D and source 608S terminals begins to oscillate at the resonant frequency of the first resonator section 601. As the current through and voltage across the inductor 124 begin to oscillate, the susceptor 132 is inductively heated. Switching the FET 608 to the OFF state, therefore acts to release the magnetic energy stored in the inductor 124 at time t_1 to heat the susceptor 132.

[0095] Figure 8 shows a trace 800 of the voltage across the first FET 608, starting from the FET 608 being in the ON state from time t_0 to t_1 . Over the time illustrated in Figure 8 the first FET 608 is turned off and on twice.

[0096] The voltage trace 800 comprises a first section 800a between times t_0 and t_1 when the first FET 608 is ON, and a second section 800b to 800d when the first FET 608 is switched off. At 800e the FET 608 is switched on again, and a third section 800f which is equivalent to the first section 800a begins while the first FET 608 remains on and the above-described process of building up of DC current through the inductor 124 repeats. Figure 8 also shows a fourth section 800g when the first FET 608 is switched off again to allow oscillation of the voltage across the FET 608, and a fifth section 800h when the first

FET 608 is subsequently switched on again.

[0097] The voltage across the first FET 608 is zero when the first FET 608 is on in sections 800a, 800f and 800h. When the first FET 608 is turned off as indicated by section 800b to 800d and also by section 800g, the first inductor 124 uses the energy stored in its magnetic field (which magnetic field was the result of the DC current built up when the first FET 608 was on) to induce a voltage that opposes a drop in the current flowing through the first inductor 124 as a result of the first FET 608 being off. The voltage induced in the first inductor 124 causes a corresponding variation in voltage across the first FET 608. During this variation in voltage, the first inductor 124 and the capacitors 606, 610 begin to resonate with each other with a sinusoidal waveform. The voltage shown by voltage trace 800 initially increases (see for example 800b) as the induced voltage in the first inductor 124 increases to oppose a drop in current due to the first FET 608 being off, reaches a peak (see for example 800c) and then, as the energy stored in the magnetic field of the first inductor 124 diminishes, decreases back to zero (see for example 800d).

[0098] The varying voltage 800b to 800d and 800g produces a corresponding varying current (not shown) and, since during the off time of the first FET 608, the capacitors 606, 610 and the first inductor 124 act as a resonant LC circuit, the total impedance of the combination of the first inductor 124 and capacitors 606, 610 is at a minimum during this time. It will therefore be understood that the maximum magnitude of the varying current flowing through the first inductor 124 will be relatively large. This relatively large varying current accordingly causes a relatively large varying magnetic field in the first inductor 124 which causes the susceptor 132 to generate heat. The time period over which the voltage across the first FET 608 varies as indicated by section 800b to 800d and by section 800g in this example depends on the resonant frequency of the first resonator section 601.

[0099] Referring now to Figures 6 and Figure 8, the circuit 600 is configured such that when the first FET 608 is off and the voltage across the first FET 608 decreases back towards 0V, the zero-voltage detector 621 detects this voltage condition and outputs a signal to the flip-flop 622 which causes the first FET 608 to be switched back to the ON state. That is, in response to this voltage condition detected within the first resonator section 601, the FET 608 is switched from the OFF state to the ON state. The zero-voltage detector 621 may be considered to detect a voltage condition indicative that a given proportion of a cycle of current oscillation between the inductive element and the capacitive element has been completed since the FET 608 was switched off. That is, the zero-voltage detector 621 detects that a half-cycle of current (and voltage) oscillation at the resonant frequency of the first resonator section 601 has been completed by the zero-voltage detector 621 detecting that the voltage across the FET 608 has returned to 0V or nearly 0V.

[0100] In some examples, the zero-voltage detector

621 may detect when the voltage across the first FET 608 has returned to at or below a voltage level 801 and as such may output a signal to cause switching of the state of the FET 608 before the voltage across the FET 608 reaches exactly 0V. As is illustrated by Figure 8, the operation of the zero-voltage detector 621 curtails oscillations of the voltage in the resonator section 601 after one half-cycle and thus results in a substantially half-sine wave voltage profile across the first FET 608. Further details of the operation of the zero-voltage detector 621 will be described below with reference to Figure 9.

[0101] When the first FET 608 is switched back on, at point 800e, a DC current driven by the DC source 118 again builds up through the first inductor 124. The first inductor 124 may then again store energy in the form of a magnetic field to be released when the first FET 608 is next switched off to initiate resonance within the first resonator section 601. As the first FET 608 is repeatedly switched on and off in this way, the above described process is continuously repeated to heat the susceptor 132.

[0102] It should be noted that the above described building up of current through the inductor 124 described with reference to Figures 7A and 7B occurs both when the FET 608 is turned on initially in response to a START signal 1011 from the controller 1001 and when the FET 608 is switched on subsequently by a zero-voltage condition detected by the zero-voltage detector 621. In the first instance, in response to the START signal 1011, the current in the inductor 124 builds up substantially linearly from 0. In the second instance, when the FET 608 is turned back on in response to a detected zero voltage condition at point 800e, some excess current is circulating in the circuit 600 (e.g. from previous cycles of switching on and off of the FET 608). As the FET 608 is turned back on following the detection of a zero-voltage condition, the recirculating current produces an initial negative current through the FET 608. Then, while the FET 608 remains on, the current through the FET 608 and inductor 124 builds up, substantially linearly, from the initial negative current value produced by the recirculating current. As the current through the inductor 124 builds up, the voltage across the current sense resistor 615 correspondingly becomes increasingly negative, in the manner described above.

[0103] In examples, switching on and off of the FET 608 may occur at a frequency of around 100kHz to 2MHz, or around 500kHz to 1MHz, or around 300kHz. The frequency at which the switching on and off of the FET 608 occurs is dependent upon the inductance L, the capacitance C, the DC supply voltage supplied by the supply 618 and further upon a degree to which current continues recirculating through the resonator section 601 and the loading effect of the susceptor 132. For example, where the DC supply voltage equals 3.6V, the inductance of the inductor 124 is 140nH, and the capacitance of the resonator section 601 is 100nF, the time for which the FET 608 remains on may be around 2700ns and the time

for a half-cycle of oscillation to complete when the FET 608 is off may be around 675ns. These values correspond to a power of around 20W being supplied from the DC voltage supply 118 to the resonator section 601. The above value of the time for which the FET 608 remains on is affected by the amount of current which recirculates in the circuit, since as described above, this recirculating current causes an initial negative current through the inductor upon switching on of the FET 608. It should also be noted that the time for the current to build up to the value which causes switching off of the FET 608 is also at least in part dependent on the resistance of the inductor 124, however, this has a relatively minor effect on the time when compared to the effect of the inductance of the resonator section 601. The time for a half-cycle of oscillation to complete (of in this example 675ns) is dependent on the resonant frequency of the resonator section 601 which is affected not only by the values of inductance and capacitance of the inductor 124 and capacitors 606, 610 respectively, but also by the effective resistance provided by loading the inductor 124 with the susceptor 132.

[0104] Thus far, the circuit 600 has been described in terms of its operation to heat the susceptor 132 by one inductor, the first inductor 124, and thus only a part of the circuit 600 used by the device 100 has been described. However, as described above, the device 100 also comprises a second inductor 126 for heating the second zone 132b of the susceptor 132. Figure 9 shows a simplified schematic of the circuit 600 comprising the second inductor 126 in addition to the first inductor 124.

[0105] As shown in Figure 9, in addition to the features described with reference to Figures 6 to 8, the circuit 600 comprises a second resonator section 701 comprising the second inductor coil 126, a third capacitor 706, a fourth capacitor 710 and a second FET 708, having a drain terminal 708D, a source terminal 708S, and a gate terminal 708G. Additionally, the circuit 600 comprises a second gate driver 723 configured to provide a gate-source voltage to the second FET gate terminal 708G. The controller 1001 is not shown in Figure 9 but the controller 1001 controls the circuit 600 in the manner described with reference to Figures 6 to 8 and additionally is configured to provide a control signal 1012 to the second gate driver 723. Some reference numerals of features of the circuit 600 already described with reference to Figure 6 have been omitted from Figure 9 for the sake of clarity.

[0106] As described above, the first inductor 124 is arranged to heat the first zone 132a of the susceptor 132 and the second inductor 126 is arranged to heat the second zone 132b of the susceptor 132. The second inductor 126, third and fourth capacitors 706, 710, and second FET 708 are arranged to form the second resonator section 701, in the same manner as the first inductor 124, first and second capacitors 606, 610, and first FET 608 are arranged to form the first resonator section 601. In one example, the third and fourth capacitors 706, 710 are also COG capacitors and may have a capaci-

tance of around 100nF. The second inductor 126 in one example has a DC resistance of around 8mΩ. When active, the second resonator section 701 operates to heat the susceptor 132 in an equivalent manner as described above for the first resonator section 601 and description of this will not be repeated here.

[0107] It will be appreciated that the value of the DC resistance of the inductors 124, 126 will have an effect on the efficiency of the circuit 600, since a higher DC resistance will result in higher resistive losses in the inductor 124, 126 and as such it may be desirable to minimise inductor DC resistance, for example by changing the number of windings, or the cross-section of the inductors 124, 126. Furthermore, it will be appreciated that an AC resistance of the inductor 124 is increased compared to the DC resistance due to the skin effect. As such, the use of Litz wire in examples provides for reducing the skin effect, and thereby reducing AC resistance and associated resistive losses from the inductors 124, 126. To give an example, where the first inductor 124 has a DC resistance of around 5mΩ and the second inductor 126 has a DC resistance of around 8mΩ, and the circuit operates at around 300kHz, the particular arrangement of Litz wire forming the coils results in effective resistances for the inductors 124, 126 of around 1.14 times their DC resistance values.

[0108] A node 700A in the second resonator section 701 is equivalent to the first node 600A of the first resonator section 601 and is electrically connected to the first node 600A and thereby to the positive terminal 118a of the DC supply 118. A node 700C is at the equivalent position in the second resonator section 701 as is the third node 600C of the first resonator section 601 and the node 700C is similarly connected to ground 616.

[0109] It is important to note that the circuit 600 is configured to be operated by the controller 1001 such that only one of the resonator sections 601, 701 is active at any one time. Examples of this operation will be described in more detail below.

[0110] During the activation of one of the resonator sections 601, 701, the zero-voltage detector 621 is configured to detect a zero-voltage condition in the active resonator section 601, 701 and thus control switching of the respective FET 608, 708 of the active resonator section 601, 701. The zero-voltage detector 621 controls when the respective FET 608, 708 of the active resonator section 601, 701, is switched back on (such as at point 800e), and example of this will now be described in more detail, with reference to Figures 8 to 10.

[0111] In the circuit 600, the zero-voltage detector 621 is configured to detect a zero-voltage condition at the second node 600B of the first resonator section 601 or at the equivalent node 700B of the second resonator section 701. When one of the first resonator section 601 and second resonator section 701 is active, the zero-voltage detector 621 detects each time the respective FET 608, 708 has been switched off, that the voltage across that FET 608, 708 has returned to zero (e.g. point 800e in

Figure 8) or, is close to zero e.g. below a level 801. In response to the zero-voltage detector 621 making this detection, a signal is output to change the state of the flip-flop 622. The respective gate driver 623 which is in operation then outputs a gate-source voltage to switch the respective FET back to the ON state.

[0112] A first small signal diode 725 connects the zero-voltage detector 621 to the first resonator section second node 600B and a second small signal diode 726 connects the zero-voltage detector 621 to the equivalent node 700B of the second resonator section 701. Specifically, anodes of the first small signal diode 725 and second small signal diodes are connected to the zero-voltage detector 621 input via a common node 701B while cathodes of the diodes 725, 726 are connected respectively to the nodes 600B, 700B.

[0113] The operation of the zero-voltage detector 621, in a particular example, will now be described with reference to Figure 10, which shows the zero-voltage detector 621 and the flip-flop 622. In Figure 10, the components which make up the zero-voltage detector 621 are enclosed by a dotted line box. The node 701B connected to the anodes of the first and second small signal diodes 725, 726 is shown. The start signal 1011 from the controller 1001 to the zero-voltage detector 621 can also be seen in Figure 13.

[0114] The zero-voltage detector 621 in this example comprises an inverter gate U103 having an input 2 from the node 701B and an output 4 connected to an input of the flip-flop 622. The inverter gate U103 is powered by connections 5 and 3 and a capacitor C108 isolates the connection 5 from ground. A logic power supply 621a of, in this example, 2.5V is applied to the input 5 and via a pull-up resistor R111 to the input 2 of the inverter gate U103. The logic power supply 621a is in this example supplied from the controller 1001. The inverter gate U103 is configured to act as an OR gate for the START signal 1011 and a zero-voltage detection signal from the node 701B. That is, the inverter gate U103 is configured to receive a logic low signal in the form of the START signal 1011 from the controller 1001 to initiate operation of the circuit 600a. The START signal 1011 may be provided by an "open drain" signal pin of the controller 1001. The inverter gate U103 is also configured to receive a logic low signal from the node 701B when one of the first and second signal diodes 725, 726 is forward biased due to one of the nodes 600B, 700B being at or near zero volts, as will be explained below. When either or both of these logic low signals is received by the inverter gate input 2 the inverter gate U103 inverts the received signal and outputs a logic-high signal to the flip-flop 622.

[0115] When the first inductor 124 is being operated to heat the susceptor 132, the second FET 708 remains off. When the second FET 708 remains off, the second small signal diode 726 has either no bias or is reverse biased depending on the voltages at the logic power source and the DC supply 118, that is, the voltage at a cathode end (nearest the node 700B) of the second small signal diode

726 is either substantially the same as or higher than the voltage at an anode end (nearest the zero-voltage detector 621) of the second small signal diode 726.

[0116] During operation of the first resonator section 601, when the first FET 608 is off and the voltage across it varies as indicated by 800b-d of Figure 8, the first small signal diode 725 is reverse biased. At the end of this variation in voltage, when the voltage reaches 0V as indicated by 800e, or is close to 0V (e.g. at or below level 801), the first small signal diode 725 becomes forward biased. Accordingly, when the first small signal diode 725 is forward biased at 800e, the signal provided to the input 2 of the inverter gate U103 becomes a logic low signal since a voltage drop is produced from the logic signal 621a across the resistor R111. As such, once this logic low signal is inverted by the inverter gate U103, a logic high signal is provided at the output 4 of the inverter gate U103.

[0117] Although in the above description the functioning of the zero-voltage detector 621 is described in relation to controlling switching of the first FET 608, it will be understood that the zero-voltage detector 621 functions in the same way, using the second small signal diode 726 instead of the first small signal diode 725, to control the second FET 708.

[0118] Still with reference to Figure 10, the flip-flop 622 comprises a clock input CLK, a reset input /RST, and an output Q. The flip-flop 622 also comprises further inputs D and VCC for supplying power, in this example the flip-flop receives the same 2.5V logic power supply 621a from the controller 1001 as the inverter gate U103 receives. The clock input CLK is connected to the output 4 of the inverter gate U103 and is configured to receive a signal therefrom. When the output 4 of the inverter gate U103 switches from logic-low to logic-high (due to the input 2 of inverter gate U103 receiving a detected zero-voltage condition or a START signal 1011 as described above) the clock input CLK of the flip-flop 622 receives a logic-high rising edge signal which "clocks" the flip-flop 622 and makes the state of the flip-flop output Q high. The flip-flop 622 comprises a further input /RST configured to receive a signal from the output of the comparator 618, by which the comparator 618 can change the state of the flip-flop 621 to cause the flip-flop output Q to be high. The flip-flop output Q is connected to the first and second gate drivers 623, 723 and on receiving a high output from the flip-flop output Q, whichever one of the gate drivers 623, 723 is active (due to receiving a signal 1021, 1022 as described above) provides a gate driver signal to its respective FET 608, 708.

[0119] In one particular example, the flip-flop 622 may switch at half of the voltage of the logic power source 621a, that is, at 1.25V in this example. This means that the forward bias voltage of the first small signal diode 725 and the voltage at the first FET drain 608D must sum to 1.25V in order that the first FET 608 is switched on. In this example therefore, the first FET 608 is switched on when its drain 608D is at 0.55V rather than at exactly 0V. It

should be noted that ideally, switching may occur at 0V across the FET 608 for maximum efficiency. This zero-voltage switching advantageously prevents the first FET 608 from discharging the capacitors 606, 610 and thereby wasting energy stored in said capacitors 606, 610.

[0120] Figure 11 shows in more detail the first and second gate drivers 623, 723 and their connection to the gates 608G, 708G of their respective FETs 608, 708. Each of the gate drivers 623, 723 has an input IN which is configured to receive a signal dependent on the heater activation signals 1021, 1022 supplied from the controller 1001. Additionally, the signals received by the inputs IN of the gate drivers 623, 723 are dependent on whether the signal output by the flip-flop output Q is high. The inputs IN are connected to the output Q of the flip-flop 622 via respective resistors R125, R128, which in this example each have a value of 2k Ω .

[0121] The gate drivers 623, 723 each have two further inputs VDD and XREF wherein each input VDD receives a 6V power supply from the controller 1001 and XREF receives a 2.5V logic voltage, which in this example is the same logic voltage supplied by the controller 1001 to the flip-flop 622 and inverter gate U103. The inputs VDD of each of the first and second gate drivers 623, 723 are connected to a 6V supply voltage and the inputs VDD are connected to ground via two buffering capacitors C120, C121. The gate drivers 623, 723 also each have a terminal GND connected to ground wherein the terminals VDD and GND act to supply power to the gate drivers 623, 723. In this example, the capacitors C120, C121 each have a value of 1 μ F. The gate drivers 623, 723 are configured to output gate drive voltages from respective outputs OUT. The outputs OUT of the gate drivers 623, 723 are connected respectively to FET gates 608G, 708G via resistors R114, R115, which in this example each have a resistance of 4.99 Ω .

[0122] Each gate driver 623, 723 is configured to receive a signal at its input IN to cause the gate driver to be activated only while a logic-high signal is provided from the flip-flop output Q and a heater activation signal 1021, 1022 is received from the controller 1001. An "open-drain" signal pin may be provided on the controller 1001 which is configured to provide the signals 1021, 1022. In one example, the

[0123] In examples, initiation of the circuit 600 for heating by one of the resonator sections 601, 701 proceeds by the controller 1001 first initiating the desired one of the gate drivers 623, 723 by a respective one of the heater initiation signals 1021, 1022. The controller 1001 then supplies the START signal 1011 to the zero-voltage detector 621. The duration of the START signal 1011 should be shorter than the period of half a cycle of oscillation by the active resonator section 601, 701 (this period may be referred to as the "resonant fly-back period"). This allows the circuit to properly begin self-oscillating in response to a detected zero-voltage condition. In another example, the order the START signal 1011 and respective heater enable signal 1021, 1022 may be

reversed such that the START signal 1011 is first applied to set the flip-flop Q output to high, and one of the heater initiation signal 1021, 1022 then applied to begin the self-oscillating of the resonator section 601, 701 corresponding to heater to which the signal 1021, 1022 is supplied.

[0124] To continue with describing in more detail the control arrangement for controlling the circuit 600, Figure 12 shows a portion of the control arrangement comprising the comparator 618 and associated components. In Figure 12, the positive terminal 118a of the DC power supply 118 is shown connecting to a node 1500A which is connected to nodes 600A, 700A of the first and second resonator sections 601, 701 respectively. The negative terminal 118b of the DC power supply is connected to a node 1500B which is equivalent to the node 600D shown in Figure 6. The node 1500B connects to ground 616 via the current sense resistor 615. Between the nodes 1500A and 1500B an arrangement of capacitors C111, C112, C115 and C116, each in this example having a capacitance of 100 μ F, are connected in parallel, providing buffering between nodes 1500A and 1500B.

[0125] Figure 12 shows in more detail components associated with the functioning of the comparator 618 for detecting that the current through the active inductor 124 or 126 has reached a given level. As described with reference to earlier figures, the comparator 618 acts to compare a voltage indicative of an amount of DC current flowing in the active inductor (124 or 126) to a control voltage 1031 originating from the controller 1001. The comparator 618 receives power via an input 6 which is connected via a 100 Ω resistor R116 to a 2.5V logic power signal, in this example supplied by the controller 1001 and the same logic signal as the signal 621a received by the flip-flop 622. The comparator power input 6 is connected to ground via a 10nF capacitor C119. A further terminal 2 of the comparator 618 is connected directly to ground.

[0126] In some examples, the controller 1001 is a micro-processing unit comprising a timer (not shown) for generating a signal which produces the control voltage 1031. In this example, the control voltage 1031 is produced by a pulse-width modulated signal PWM_DAC generated by the controller 1001. The timer of the controller 1001 generates a pulse-width modulated square waveform, with, for example, a magnitude of around 2.5V and a frequency of around 20kHz and having a particular duty cycle. The pulse-width modulated signal PWM_DAC is filtered by 10nF capacitors C127 and C128, and by two 49.9k Ω resistors R121, R123 and a 10k Ω resistor R124 to provide a substantially constant control voltage 1031 at the frequency at which the controller 1001 controls the control voltage 1031 (of, e.g., around 64Hz in examples). To adjust the control voltage 1031, the controller 1001 in examples is configured to adjust the duty cycle of the pulse-width modulated signal PWM_DAC applied to the circuit 600. As such, the components positioned between the input PWM_DAC and the positive terminal of the comparator 618 effectively

provide for the control voltage 1031 to be produced by a pulse-wave modulated signal and for the control voltage 1031 magnitude to be adjusted by adjusting the duty cycle of this pulse wave modulated signal. The control voltage line 619 shown in Figures 6 and 9 may thus be replaced by these components. However, in other examples, the control voltage 1031 may produced by a substantially constant voltage supplied, for example, by the controller 1001. In such examples, some or all of the components for shown in Figure 12 for filtering the signal PWM_DAC may not be present.

[0127] The node 1500B which is input to the comparator 618 positive input is, as mentioned above, equivalent to the node 600D of the circuit 600. It can be seen from Figure 12 that, as described with reference to the simplified schematic shown in Figure 6, the node 1500B is connected via the resistor 617a to the positive input of the comparator 618. As such, the operation of the comparator 618 is as described above: to receive an input at its positive terminal which is dependent on the control voltage 1031 and the voltage across the current sense resistor 615. When the voltage at the positive terminal of the comparator 618 reaches ground voltage, a signal /FF RST is output, via a resistor R118, to the flip-flop 622 input /RST to change the state of the flip-flop 622 and thereby switch the active FET 608/708 off.

[0128] Figure 13 shows further components for a particular example of the control arrangement for the circuit 600. The components shown in Figure 13 define current sense apparatus 1300 for providing a signal I_SENSE indicative of an amount of current drawn from the DC voltage supply 118 during operation of the circuit 600. From this signal, the controller 1001 may determine a current drawn from the voltage supply 118, and may use this along with a value of the voltage supplied by the DC voltage supply 118 to determine a value for a power supplied to the circuit 600. In some examples, as will be described below, a determined value of power may be used by the controller 1001 for controlling the circuit 600.

[0129] An input 1301 to the current sense apparatus 1300 is provided via the resistor R120 shown in Figure 12. The input is therefore connected to the node 1500B via the resistor R120 and receives a voltage indicative of the voltage across the current sense resistor 615. The current sense apparatus 1300 operates as a low-side current sensing apparatus for the circuit 600. In that regard, the current sense apparatus 1300 comprises an op-amp U110 running on a voltage of 3.8V supplied to an input 5 of the op-amp U110 (component type TS507) set up for low-side current sensing using the current sense resistor 615, as will be well understood. A transistor U109 with built-in bias resistor (component type RN4986) acts to switch a 2.5V supplied by the controller 1001 up to the 3.8V supply for the op-amp U110. The power supply line from the transistor component U109 is connected to ground via a 10nF capacitor C132. Further, a 1k Ω resistor R130 is connected between the positive input of the op-amp U110 and ground and a

412k Ω resistor R129 is connected between the 2.5V input from the controller 1001 and the positive input of the comparator U110. The negative terminal of the op-amp U110 receives a voltage dependent on the voltage across the current sense resistor 615. A resistor R131 and capacitor C133 in series provide filtering of the voltage signal received via the input 1301. A further resistor R133 (in this example having resistance of 97.6k Ω) and a 10nF capacitor C134 are connected in parallel between the input to the negative terminal of the op-amp U110 and the output of the op-amp U110 such that op-amp operates in a closed-loop mode.

[0130] The op-amp U110 operates to output a voltage signal I_SENSE to the controller 1001 which is indicative of the current through the current sense resistor 615 and thus allows the controller 1001 to determine the current drawn from the DC voltage supply 118 through the circuit 600.

[0131] It should be noted that having regard to the first and second FETs 608 and 708, and the topology of the circuit 600, the phasing of the first and second inductor coils 124 and 126 with respect to each other may be chosen such that when the first inductor coil 124 is being operated, current sufficient to cause significant heating of the susceptor 132 is prevented from flowing in the second inductor coil 126, and when the second inductor coil 126 is being operated, current sufficient to cause significant heating of the susceptor 132 is prevented from flowing in the first inductor coil 124.

[0132] As described above, the first 608 and second 708 FETs effectively act as diodes 608a, 708a when switched off and so may conduct a current if they are forward biased (i.e. the FETs are not perfect switches). Accordingly, in examples the circuit 600 may be configured so that when one of the first 124 and 126 inductor coils is active to heat the susceptor 132, the voltage induced across the other inactive inductor coil does not forward bias the intrinsic diode of the FET associated with that inactive inductor coil but instead reverse biases it.

[0133] The effect of the above described control arrangement being configured to control the switching arrangements 608, 708 of the circuit 600 in response to detected voltage conditions is that when one of the first resonator section 601 and the second resonator section 701 is active (i.e. its gate driver 623, 723 is activated by the controller 1001) that resonator section "self-oscillates", while the other section remains inactive. That is, switching of the respective FET 608, 708 in the resonator section 601, 701 repeats at a high frequency as a first voltage condition (detected by the comparator 618) causes the FET to be switched from on to off, and a second voltage condition (detected by the zero-voltage detector 621) causes the FET to be switched from off to on.

[0134] The controller 1001 is configured to control the induction heating circuit 600 of the device 100 such that only one of the first inductor 124 and the second inductor 126 is active at any one time. The controller 1001 is

configured to determine at a pre-determined frequency which of the first inductor 124 and the second inductor 126 to activate.

[0135] In examples, during usage of the device 100 the controller 1001 determines at the pre-determined frequency, i.e. one time for each of a plurality of pre-determined time intervals, which of the first resonator section 601 and the second resonator section 701 to activate. In one example, each time the controller 1001 determines which of the first resonator section 601 and the second resonator section 701 to activate, the controller 1001 may determine to activate that resonator section to heat the susceptor 132 for the duration of the next pre-determined interval. That is, where the pre-determined frequency (which may be referred to as an "interrupt rate") is 64Hz, for example, the controller 1001 may determine at pre-determined intervals of 1/64s, which resonator section 601, 701 to activate for a following duration of 1/64s until the controller makes the next determination of which resonator section 601, 701, at the end of the following 1/64s interval. In other examples, the interrupt rate may be, for example, from 20Hz to 80Hz, or correspondingly the pre-determined intervals may be of length 1/80s to 1/20s. In order to determine which inductor 124, 126 is to be activated for a pre-determined interval, the controller 1001 determines which susceptor zone 132a, 132b should be heated for that pre-determined interval. In examples, the controller 1001 determines which susceptor zone 132a, 132b should be heated with reference to a measured temperature of the susceptor zones 132a, 132b, as will be described below.

[0136] Figure 14 shows a flowchart representation of an example method of determining which of the two resonator sections 601, 701, should be activated for a particular pre-determined interval. In this example, the controller 1001, determines which of the first 601 and second 701 resonator sections to activate for the pre-determined interval based on a present temperature T1 of the first susceptor zone 132a heated by the first inductor 124 and a present temperature T2 of a second susceptor zone 132b heated by the second inductor 126. In an example, the present temperatures T1 and T2 of the first 132a and second 132b susceptor zones may be measured by respective thermocouples (not shown) attached to each zone of the susceptor 132. The thermocouples provide an input to the controller 1001 allowing the controller 1001 to determine the temperatures T1, T2. In other examples, other suitable means may be used to determine the respective temperatures of the susceptor zones 132a, 132b.

[0137] At block 1051, the controller 1001 determines a present value of the temperature T1 and compares this to a target temperature target1 for the first zone 132a arranged to be heated by the first inductor 124. The target temperature target1 of the first zone 132a has a value which may vary throughout a usage session of the device employing the circuit 600. For example, a temperature profile may be defined for the first zone defining values for

target1 throughout a usage session of the device 100.

[0138] At block 1052 the controller 1001 performs the same operation as was performed for the first inductor 124 at block 1051 and determines whether the present temperature T2 of the second zone 132b is below the target temperature target2 for the second zone 132b at this time. Again, the target temperature of the second zone 132b may be defined by a temperature profile defining values of target2 throughout a usage session. The temperature of the second zone 132b may, similarly to the first zone 132a, be measured by any suitable means such as by a thermocouple.

[0139] If the answers at block 1051 and block 1052 are both "no", i.e. both suscepter zones 132a, 132b are presently at or above their respective target temperatures target1, target2, then the controller 1001 determines neither of the first and second resonator sections 601, 701 should be activated for the next pre-determined interval.

[0140] If the answer at block 1051 is "no" and the answer at block 1052 is "yes", i.e. the first zone 132a is at or above its target temperature target1 but the second zone 132b is below its target temperature target2, then the controller 1001 determines that the second resonator section 701 should be activated to heat the second zone 132b for the next pre-determined interval.

[0141] If the answer at block 1051 is "yes" and the answer at block 1052 is "no", i.e. the first zone 132a is below its target temperature target1 and the second zone 132b is at or above its target temperature target2, then the controller 1001 determines that the first resonator section 601 should be activated to heat the first zone 132a for the next pre-determined interval.

[0142] If the answer at block 1051 is "yes" and the answer at block 1052 is "yes", i.e. both the first 132a and second 132b zones are below their respective target temperatures target1, target2, then the controller 1001 continues to block 1053. At block 1053 the controller 1001 effectively acts to alternate activation of the first resonator section 601 and second resonator section 701 for each pre-determined interval that both zones 132a, 132b remain below their respective target temperatures.

[0143] In one example, in order to alternately activate the first 601 and second 701 resonator sections, at block 1053 the controller 1001, in some examples, determines if an even number of predetermined intervals has elapsed since the start of the session. If an even number of predetermined intervals has elapsed since the start of the session then the controller 1001 determines that the first resonator section 601 should be activated for the next interval. If an odd number of predetermined intervals has elapsed since the start of the session then the controller 1001 determines that the second resonator section 701 should be activated for the next interval. In other examples, it should be understood, that the controller 1001 may instead activate the second resonator section 701 when an even number of intervals has elapsed and the first resonator section 601 when an odd number of

intervals has elapsed.

[0144] In certain examples, the circuit 600 is configured such that once one of the resonator sections 601, 701 is activated by receipt of a signal 1021 or 1022 at one of the gate drivers 623, 624, the that resonator section 601/701 continues to operate, i.e. self-oscillate, until deactivated by the controller 1001, for example by providing a different signal to the gate driver of that resonator section 601/701. As such, upon determining which of the resonator sections 601, 701 to activate during a given interval, the controller 1001, in order to initiate this activation may deactivate one of the resonator sections 601, 701 which was active during a previous interval.

[0145] To illustrate an example of block 1053 where method 1050 shown in Figure 14 is performed with intervals of 1/64s, if the controller 1001 determines that both zones 132a, 132b are below their respective target temperatures target1, target2 and an even number of 1/64s intervals has elapsed since the start of the usage session of the device 100, then the controller 1001 activates the first resonator section 601 for the next 1/64s interval while the second resonator section 701 is rendered inactive, which in examples requires the controller 1001 deactivating the second resonator section 701. If after this next interval of 1/64s both zones 132a, 132b remain below their respective target temperatures target1, target2, then for the following 1/64s interval the controller 1001 activates the second resonator section 701 while the first resonator section 601 is rendered inactive, which in examples requires the controller 1001 deactivating the second resonator section 701. For each interval in which both zones 132a, 132b remain below their respective target temperatures this alternating between activating the first 601 and second 701 resonator sections continues.

[0146] Altogether, the method 1050 has the effect that the two inductors 124, 126 are never activated at the same time. Where it is determined that both inductors 124, 126 require activation to bring their respective zones 132a, 132b to target temperature the controller 1001 alternates the supply of power to the inductors 124, 126 at the pre-determined frequency to bring both zones 132a, 132b up to their respective target temperature. It can therefore be seen that, for example, during a period of a usage session comprising a plurality of intervals where the first zone 132a, is substantially below its target temperature and the second zone 132b is at or above its target temperature, the method 1050 has the effect that power may be supplied to the first resonator section 601 for close to 100% of this period. However, for a period of a usage session comprising a plurality of intervals in which both zones 132a, 132b are below their target temperatures, each inductor may receive power for roughly 50% of this period.

[0147] As mentioned, when both zones 132a, 132b are at their target temperatures, power may not be supplied to either inductor. In certain examples, during a heating session which lasts a predetermined period (such as 3,

3.5, 4 or 4.5 minutes), neither of inductors may be receiving power for greater than about 75% of the time or greater than about 80% of the time. In other words, both inductors may be at their target temperatures for greater than 75% of the time, or greater than 80% of the time, such that a constant supply of power is not needed. Instead, power is supplied only when the temperatures of the zones 132a, 132b falls below their respective target temperatures. In a particular example, a heating session lasts for a period of 260 seconds and the first inductor 124 receives power for a total of about 25 seconds during the heating session and the second inductor coil 126 receives power for a total of about 19 seconds during the heating session. More generally, each inductor may receive power for between about 7% and 15% of the time during a heating session, meaning that the inductors are operating for between about 14% and 30% of the time.

[0148] The power supplied for each 1/64s interval can be determined as the product of the DC voltage across the DC supply 118 during this interval and the average DC current drawn from the DC supply 118 during the interval. In a particular example, when an inductor is being operated during an interval, the power may be between about 15W and about 25W, or more preferably between about 20W and about 23W.

[0149] The energy consumed by an inductor during this interval is determined by the product of the power by the length of the interval. Accordingly, the energy consumed by an inductor during the interval may be between about 0.31J and about 0.36J. When the inductors are not being operated (because the zones 132a, 132b are at their target temperatures), the power supplied to the inductors, and energy consumed by the inductors, may be negligible. For example, the energy consumed by the inductors may be less than about 0.01J.

[0150] The first and second inductors 124, 126 may be collectively known as a heater/heating assembly. As mentioned above, assuming the inductors are only activated for about 25% of the time during the heater session, the total energy consumed by the inductors during the session is between about 1200J and about 1400J. Assuming the inductors are only activated for about 20% of the time during the heater session, the total energy consumed by the inductors is between about 1000J and about 1150J. Depending upon the characteristics of the heater assembly, environment, and article received in the device, the total energy consumed by the inductors may be between about 1000J and about 1400J.

[0151] In one example, the DC supply 118 (i.e. the battery) has a battery capacity of about 3000mAh and a voltage of around 3-4V, giving a capacity of between about 30,000J and about 35,000J. In a particular example, the battery capacity is about 33,000J. This allows the DC supply 118 to provide power for between about 25 and 30 heating sessions.

[0152] In a particular example, when the device is inactive, the current draw is about 0.1mA. Most of this current draw is quiescent current drawn by the voltage

regulator of the DC supply 118. In an example, the regulator is a 2.5V regulator. Some of this current may be due to small leakage currents on any additional powered integrated circuits present in the device, such as the integrated circuit associated with the charging socket 114. Assuming the battery has a voltage of about 3.7V, the power consumed by the device when it is inactive may be about 0.370mW. Preferably, an inactive device 100 consumes less than about 1mW, or less than about 0.5mW or less than about 0.4mW.

[0153] If the controller 1001 is active, the current draw may be about 3mA. The controller 1001 therefore consumes about 0.01W in use. In one example, the controller 1001 has a 16MHz clock. Preferably, the controller 1001 consumes less than about 0.05W, or less than about 0.03W or less than about 0.01W.

[0154] The device 100 may also comprise a visual indicator such as a plurality of LEDs. As briefly mentioned above, Figure 2 shows a second printed circuit board 138. Mounted on the second printed circuit board 138 are 4 LEDs. The LEDs can be illuminated to indicate certain events to a user, such as when the device is ready for use. Each LED may draw a current of about 2mA when at maximum brightness or intensity. When all 4 LEDs are at maximum brightness, they consume a combined power of about 0.03W. Preferably, the visual indicator consumes less than about 0.05W, or less than about 0.04W or less than about 0.03W. The LEDs may be illuminated during a heating session, for example.

[0155] Accordingly, during a heating a session, the heating assembly may consume between about 15W and about 25W. The other electrical components within the device (i.e. all components excluding the inductors 124, 126) may consume a total power of about 0.04W (about 0.03W for the LEDs, and about 0.01W for the voltage regulator, controller 1001 and other leakage currents). Preferably, the power consumption of the electrical components is less than about 0.1W, or less than about 0.05W.

[0156] In the above examples, it will be appreciated that the power will change with the battery 118 voltage. In the above examples, the battery 118 voltage is assumed to be about 3.7V.

[0157] In an example, the power consumption of the electrical components is less than about 0.5% of the power consumption of the heating assembly (i.e. inductors). Preferably, the power consumption of the electrical components is less than about 0.2% of the power consumption of the heating assembly. For example, the power consumption of the heater assembly (i.e. inductors) may about 20W and the power consumption of the other electrical components is about 0.04W. Accordingly, the power consumption of the electrical components is about 0.2% of the power consumption of the heating assembly.

[0158] In examples, the controller 1001 is also configured at pre-determined intervals, which in examples coincide with the pre-determined intervals at which the

method 1050 is performed, to determine a power being supplied to one of the resonator sections 601, 701 from the DC supply 118.

[0159] As described above, with reference to Figures 9 to 11 in particular, in order to control which of the first resonator section 601 and second resonator section 701 is active at any one time, the controller 1001 as well as transmitting a START signal 1001 to initiate operation of the circuit 600 is configured to selectively transmit a first heater operation signal 1011 to the first gate driver 623 to activate the first resonator section 601 or a second heater operation signal 1012 to the second gate driver 723 to activate the second resonator section 701.

[0160] For example, when the controller 1001 initiates operation of the circuit 600 and the controller 1001 transmits the first heater operation signal 1011, the circuit 600 operates as described above to activate the first inductor 124 to heat the first susceptor zone 132a. When the controller 1001 transmits the second heater operation signal 1012 the circuit 600 operates to activate the second inductor 126 to heat the second susceptor zone 132b. If the controller 1001 transmits neither of the first heater signal 1011 and the second heater signal 1012 then neither inductor 124, 126 is activated and the susceptor 132 is not heated.

[0161] The controller 1001 is configured to control the power supplied from the DC voltage supply 118 to the circuit 600 for inductive heating of the susceptor 132 based on a comparison of a measurement of power supplied to the circuit 600 and a target power. The controller 1001 is configured to control the power supplied to the circuit 600 by controlling the switching arrangement of the circuit 600, i.e. by controlling switching of the FETs 608, 708. The controller 1001 may control switching of the FETs 608, 708 by setting the control voltage 1031 which determines the DC current which is allowed to build up in the inductor 124, 126 corresponding to that FET 608, 708 before the FET 608, 708 is switched off.

[0162] Figure 15 shows an example method 1100 performed by the controller 1001 to control the power supplied to the circuit 600. At block 1101 the controller 1001 determines the power P supplied from the DC supply 118 to the circuit 600. For example the controller 1001 may determine an average of the power supplied to the circuit 600 during the previous pre-determined interval. In examples, the power P being supplied to the circuit 600 during an interval may be determined by measurement of the voltage across and DC current being driven through a given one of the resonator sections 601, 701. The controller 1001 may then determine the product of the voltage across and DC current through the given one of the resonator sections 601, 701 to determine the power P supplied to that resonator section 601, 701.

[0163] In examples, the determined power P is an average power supplied from the DC supply 118 over the pre-determined interval which may be determined by determining a product of the average DC voltage across the DC supply 118 and the average DC current drawn

from the DC supply 118 over the previous interval.

[0164] In the example device 100, the DC supply 118 is a battery which is connected to the controller 1001, and the controller 1001 then outputs the voltage of the DC supply 118 to the circuit 600. The controller 1001 is configured to determine the DC voltage supplied by the battery 118. The current drawn from the battery 118 is determined by the operation of the current sense apparatus 1300. The controller 1001 determines the DC voltage and DC current once for every 1/64s interval. The DC voltage can be considered to be essentially constant over this short time period. However, the current is varying at a rate dependent on the rapid rate of switching on and off the circuit. As described above, this is around 300kHz in some examples. The current sense apparatus 1300 as described above with reference to Figure 13, outputs a signal I_SENSE which is filtered to remove this around 300kHz signal. An average DC current for the 1/64s interval is therefore obtained by taking a measurement of this filtered signal I_SENSE, and the measurement of I_SENSE is taken just before the end of the 1/64s interval in order to allow the signal from the filter to settle. The controller 1001 thereby obtains a DC voltage and DC current measurement for the 1/64s interval and can calculate a product of these values to obtain the determined power P. This determined power P may be considered to be an average of the power supplied by the DC supply 118 over the 1/64s interval.

[0165] At block 1102 the supplied power P determined at block 1101 is compared to a target power. Where the determined power P is an average power over the pre-determined interval, the target power is a target average power over the same interval. In one example, the target power is a target for the average power supplied over the pre-determined interval and may have a value of between 10 and 25W, or between 15 and 23W, or around 20W. In this example, the target power is a range, for example, 20-21W or of 15-25W. The controller 1001 may accordingly at block 1102 compare the supplied power value P determined at block 1101 to the target range and determine whether the supplied power is below the range, within the target range, or above the target range. For example, where the target range is 20-21W, at block 1102 the controller 1001 determines whether $P < 20W$, or $20W \leq P \leq 21W$, or $P > 21W$.

[0166] Based on the comparison of the supplied power P to the target range, the controller 1001 determines whether and how to adjust the power for the next pre-determined interval with the aim of bringing the actual power supplied to the active inductor 124 or 126 during the next pre-determined interval towards the target power range. That is, if the supplied power P is below the target range, then the controller 1001 determines to increase the power supplied to the circuit 600 over the next pre-determined interval. If the supplied power P is above the target range, then the controller 1001 determines to decrease the power supplied to the circuit 600 over the next pre-determined interval. If the supplied

power P is below the target range, then the controller 1001 determines not to adjust the power supplied to the circuit 600 over the next pre-determined interval.

[0167] Due to the configuration of the circuit 600 described above, the supplied power P for a given pre-determined interval is dependent on the value of the control voltage 1031 for that interval. Taking the example of one 1/64s interval for which the first resonator section 601 is active, this 1/64s interval comprises many repeating cycles comprising sections 800a to 800e of the voltage trace 800 and repeats thereof. For each cycle during the period of time t_1 to t_0 the resonator section 601 is allowed to resonate, and since for this period the FET 608 is off, no power is drawn from the DC supply 118 through the first resonator section 601. Substantially all of the power drawn from the DC supply 118 during the given 1/64s interval to power the resonator section 601 is thus drawn during the period between t_0 and t_1 while the inductor 124 is being "energised" with current, i.e. while the FET 608 is on. The time between t_1 and t_0 is determined by the resonant frequency of the first resonator section 601. This resonant frequency may remain substantially constant, at least throughout a given 1/64s interval (although may vary over the period of operation of the circuit 600 due to dependence on coil and susceptor temperature and battery voltage). The length of time t_0 to t_1 is determined by the value of the control voltage 1031, as well as the DC voltage supplied by the DC supply 118 and the resistance and inductance of the first resonator section 601 (the same applying for the second resonator section 701). That is, for a given DC supply voltage, the control voltage 1031 sets the current I_1 which is allowed to build up in the inductor 124 between t_0 and t_1 , but where the DC supply voltage is reduced, the time required to build up a given value of I_1 is increased. As such, the average power supplied during the 1/64s interval is dependent on the value of the control voltage 1031.

[0168] In examples, therefore, in order to control the power supplied to the circuit 600 during the next interval the controller 1001 sets the value of the control voltage 1031 for the next interval. In examples, for a given DC supply 118 over a pre-determined interval during which one of the resonator sections 601, 701 is active, a larger positive value of the control voltage 1031 results in a larger value of power P being delivered to the circuit 600. Therefore, in such examples, where the controller 1001 determines that the supplied power P over the last interval was above the target range, the controller 1001 reduces the control voltage 1031 for the next interval. Where the controller 1001 determines that the supplied power P over the last interval was below the target range, the controller 1001 increases the control voltage 1031 for the next interval. And, where the controller 1001 determines that the supplied power P over the last interval was above the target range, the controller 1001 leaves the control voltage 1031 unchanged for the next interval.

[0169] It should be noted that in one example of the above method 1100 the power supplied P is determined

at block 1101 is a power supplied to a particular one of the resonator sections 601, 701. For example, the power P may be determined by measuring the voltage across the first resonator section 601 and the DC current through the first resonator section 601. In such an example, it is the power P supplied to the first resonator section 601 which is used to control the control voltage 1031. It should also be noted that for a given control voltage 1031, in some examples, the power supplied to each of the inductors 124, 126 when the respective resonator sections 601, 701 are active may be different. This may be, for example, because the inductors 124, 126 have different values of inductance or DC resistance, or the capacitance of the two resonator sections 601, 701 is not equal. Therefore, in this example, during a given pre-determined interval, a target power outside of the target power range may be supplied to the second resonator section 701 but since the control voltage 1031 is controlled based on the power P supplied to the first resonator section 601, in this example the controller 1001 may not adjust the control voltage 1031.

[0170] For example, for a given value of the control voltage 1031, the controller 1001 may determine at block 1101 that an average power of 20W was supplied to the first resonator section 601 over a given interval, with the target voltage in this example being 20-21W. At block 1102 the controller 1001 determines that the supplied voltage was within the target range and accordingly the controller 1001 determines not to adjust the control voltage 1031. Consider that for the next pre-determined interval, the controller 1001 determines (by the example method 1050) that the second resonator section 701 and not the first resonator section 601 is to be activated. For the given value of the control voltage 1031, in this example, 22.5W is delivered due to differences in the electrical properties of the first 601 and second 701 resonator sections. However, in this example, at block 1102 the controller 1001 compares the last measured value of power P delivered to the first resonator section 601 and therefore determines at block 1103 not to adjust the control voltage 1031. As such, in an example of the method 1100 the actual power supplied to the circuit 600 may be outside of the target range. However, this may allow for controlling the power supplied to the inductors 124, 126 by measuring only the power P supplied to one of the resonator sections 601, 701. This may provide a simple and useful solution to maintain the power supplied to the circuit 600 to within an acceptable range if, for example, the resonator sections 601, 701 and components thereof have roughly similar electrical properties.

[0171] As mentioned above, in some examples, the DC supply 118 is a battery with a voltage of around 2 to 10V, or 3 to 5V, or in one example around 4.2V. In some examples, the DC voltage produced by the DC supply 118 may change, e.g. decrease, over the time that the circuit 600 is operated. For example, where the DC voltage source 118 is a battery, the battery may initially supply a voltage of 4.2V but the voltage supplied by the

battery may reduce as the battery depletes. After a given period, therefore, the DC voltage source 118 may supply, for example, 3.5V instead of an initial 4.2V.

[0172] As described above, at a given supply voltage, the value of the control voltage 1031 controls the amount of current which is allowed to build up in the active inductor 124/126 before the respective FET 608/708 is switched off. Power is supplied from the DC voltage supply 118 to "energise" the active inductor 124/126 by allowing a buildup of DC current when the FET 608, 708 is on. As was also described above, the time t_1 for the current to build up to the value which causes switching of the FET 608/708 is dependent on the DC voltage supply. Therefore, for example, if the voltage supplied by the DC supply 118 reduces, the rate at which current builds up in the inductor coil 124 reduces, resulting in reduced power P being supplied to the circuit 600.

[0173] The example method 1100 may provide for a target power to be maintained even in the event that the supplied voltage from the DC supply 118 changes. That is, since an actual supplied power P is determined and used to control the control voltage 1031, the controller 1001 can act to maintain a target power by adjusting the control voltage 1031. For example, where the battery level has depleted, the controller 1001 measures that the power P supplied to the circuit 600 at a given control voltage 1031 has reduced, and acts to increase the power P supplied to the circuit by increasing the control voltage 1031. As such, a target power level may be maintained while a battery used to power the circuit 600 depletes. This is advantageous since maintaining a target power level may provide for optimal efficiency of operation of the induction heating circuit 600. For example, maintaining a substantially constant power supplied allows for consistent heating of the aerosolisable material 110a regardless of supply voltage. Similarly, the example method 1100 provides for providing a substantially constant power regardless of other changing factors in the circuit which might affect the amount of power delivered, such as different loading on the circuit 600 being provided by the susceptor 132 when the susceptor 132 temperature increases. This provides a consistently good experience for the consumer, for example by providing a consistent time to first puff, i.e. a consistent time between the device 100 being activated and being ready to provide aerosol to be inhaled by the user.

[0174] In another example, the measured power value P upon which control of the control voltage 1031 is based is changed throughout a usage session. For example, during a particular usage session, for a first part of the usage session (e.g. a first ~60s of the usage session), the temperature profile may be such that the first inductor 124 is primarily active, while the second inductor 126 is inactive. For this first part of the usage session it may be appropriate to base control of the control voltage 1031 on measurements of the power delivered to the first resonator section 601. However, later in the session, again e.g. due to the temperature profile for the session,

it may be that the second inductor 126 is primarily active, while the first inductor 124 is active for less of the time. Thus, for a second part of the usage session (e.g. after ~60s), it may be advantageous to control the control voltage 1031 based on the measurements of power delivered to the second resonator section 701. The controller 1001 may accordingly switch from basing control of the control voltage 1031 on measurements of power supplied to the first resonator section 601 to basing control of the control voltage 1031 on measurements of power supplied to the second resonator section 701. In this way, the target power may be more closely adhered to throughout a usage session, since, for example, the control voltage 1031 is being set based on a comparison of the actual power being delivered to the active inductor 124, 126 to the target power range.

[0175] In some examples, where the controller 1001 determines at block 1103 that the power should be adjusted, the controller 1001 may adjust the control voltage 1031 in pre-determined steps. For example, the controller 1001 may be configured to adjust the control voltage 1031 by a pre-determined amount per pre-determined time interval. Where at block 1102 the controller 1001 determines that the supplied power P was below the target power range the controller 1001 may increase the control voltage 1031 by a pre-determined number of volts for the next pre-determined interval. Conversely, where at block 1102 the controller 1001 determines that the supplied power was above the target power range the controller 1001 may increase the control voltage 1031 by a pre-determined amount for the next pre-determined interval.

[0176] In the example described above with reference in particular to Figure 12, the control voltage 1031 is produced by a pulse-wave modulated signal PWM_DAC. The signal PWM_DAC, as described above has a rectangular waveform at 2.5V. The duty signal of the signal PWM_DAC is controllable by the controller 1001 which sets a value of 0 to 800 for the PWM_DAC duty cycle, this value corresponding to a duty cycle of 0% at 0 and 100% at 800. The signal PWM_DAC when filtered provides the substantially constant control voltage 1031 and therefore the settings of from 0 to 800 of the duty cycle of the PWM_DAC signal provide for the control voltage 1031 to have a magnitude of from 0 to 2.5V. In this example, the controller 1001 may adjust the duty cycle setting of the PWM_DAC signal by a set amount, such as 8 out of 800, or leave the setting unchanged, for each pre-determined interval. In another example, the controller 1001 may provide for the control voltage 1031 to be adjusted by some other means, and if the controller 1001 determines that the control voltage 1031 should be adjusted, the controller 1001 may adjust the control voltage 1031 by, e.g., 1%, or 2%, or 5% of the maximum value of the control voltage 1031 for the next pre-determined interval.

[0177] In some examples, when operation of the circuit 600 is initiated by the controller 1001, e.g. to start a use session of the device 100 comprising the circuit 600, the

control voltage 1031 is set to a pre-determined initial value. In one example, a value of the control voltage 1031 (for example, a duty cycle setting of the signal PWM_DAC which produces this value of the control voltage 1031) which corresponds with a target power level is determined during setup of the circuit 600. That is, the power delivered to the circuit 600 may be determined (e.g. measured or determined theoretically) for a number of values of the control voltage 1031, for example to produce a calibration curve. A value of the control voltage 1031 corresponding to the target power may then be determined. In one example, the DC supply 118 may supply 4.2V and to achieve a target power of 20W the controller 1001 may determine in an example calibration a value for the duty cycle of the PWM_DAC signal setting of around 344 out of 800.

[0178] In one example, the controller 1001 is configured to set the control voltage 1031 at an initial value which is based on this determined value of the control voltage 1031. For example, the initial value of the duty cycle of PWM_DAC which determines the control voltage 1031 may be set at half of the determined value corresponding to the target power. For example, where the duty cycle setting for the control voltage 1031 found to correspond with the target power is 344 out of 800, the controller 1001 may begin the session with the setting being set at 152 out of 800, and increase the setting by a pre-determined amount with every pre-determined interval until the measured power P is within the target range. This may have the effect that at the start of a usage session, the power delivered is well below the target power and the power delivered may then ramp up (by ramping up by the controller 1001 of the control voltage 1031) until it reaches the target power range. This initial ramping up of the power delivered may provide for improved safety in operation of the circuit 600, preventing overheating of the susceptor at the start of a session and allowing the circuit 600 to respond to the actual power supplied as determined by the controller 1001.

[0179] In one example, the pre-determined interval is the same pre-determined interval as is used by the controller 1001 in the method 1050 of determining which of the first 124 and second 126 inductors to activate. In one such example, as mentioned above, the pre-determined intervals are of length 1/64s. The length of the pre-determined interval (or equivalently the interrupt rate) may be chosen to provide an advantageous time interval at which the controller can monitor the circuit and adjust parameters accordingly. For example, an interrupt rate of 64Hz, or within a range of approximately 10-100Hz may be used. At these example interrupt rates, the controller 1001 may measure increases in temperature of the susceptor zones at a sufficiently high rate that it may determine to stop heating by a particular inductor 124, 126 before a zone 132a, 132b of the susceptor 132 can increase too far above its target temperature. Similarly, examples given for the interrupt rate may provide an advantageous frequency at which the control voltage

1031 may be adjusted to allow appropriate control of power supplied to the inductors 124, 126 to within a safe target range.

[0180] In an example method of operation of the circuit 600, a target power for use by the controller 1001 in controlling power delivered to the circuit 600 is pre-determined based on characteristics of a planned usage session. For example, the target power range may be adjusted throughout a usage session.

[0181] Figure 16 shows a schematic example of a temperature profile target1 for a portion of a usage session, which in this example is a target temperature for the single susceptor zone 132a. In this example, initially at a first part 1201 of the portion of the usage session, the first zone 132a is substantially below its target temperature target1. At this first part 1201, the circuit 600 is operating to bring the first zone 132a up to the target temperature target1. At such an example part of the usage session, a target power P1 may have a range of values of, for example, 20-21W. The target power during the first part 1201 of the session may be relatively high in order to bring the susceptor 132, and therefore the aerosolisable material 110a, up to temperature quickly to a temperature suitable for producing aerosol for inhaling by the user.

[0182] As the usage session progresses, the first zone 132a substantially reaches its target temperature target1. A second part 1202 of the usage session may be defined beginning shortly after the first zone 132a reaches its target temperature target1. For instance, for this part 1202 of the usage session, the first zone 132a may be substantially at its target temperature target1, of e.g. 250°C, and may be being maintained at the target temperature target1 according to the method 1050. Similarly, although this is not shown in Figure 16, the second zone 132b may be being maintained at its own target temperature target2 by the method 1050 (and the target temperature target2 of the second zone 132b may define a different temperature profile to that defined by target1).

[0183] The part 1202 in the usage session after the first zone 132a substantially reaches temperature target1 may be characterised in that the controller 1001 is operating to maintain the temperature of the first zone 132a (or of both zones 132a, 132b) rather than to bring the temperature of the first zone 132a up to its target value target1, as in the first part 1201. As such, during the part 1202 of the usage session, relatively little power may be required to be supplied to the susceptor zone 132a to maintain the target temperature target1, when compared to the power required to bring the susceptor zone 132a up to the target temperature target1. At the second part 1202 of the usage session, it may be advantageous to reduce the value of target power P1 compared to its value in part 1201. In one example, the target power level P1 may be reduced from 20-21W in part 1201 to around 15W during part 1202 of the usage session. Reducing the target power P1 in this way may be advantageous in some examples because by using a lower level of power energy

losses in the circuit may be reduced, and thus efficiency may be increased..

[0184] For a third part 1203 of the usage session, the value of the target temperature target1 is 0, i.e. the first inductor 124 is not to be activated. At this point, the target power P1 may also be reduced to 0 if the usage session has come to an end, or if the second inductor 126 is still being activated, then the target power P1 may remain at a non-zero value while the second inductor 126 is activated. Accordingly, the target power may take into account the temperature profile of both zones 132a, 132b at any one point in the usage session. If a part of the usage session, for example, requires one of the zones to be significantly increased in temperature, then a relatively high target power may be appropriate. Conversely, for parts of a usage session where neither zone 132a, 132b requires substantial heating, a relatively low target power may be used.

[0185] As mentioned above, use of lower power levels during certain periods of a usage session may provide advantages in that an energy saving may be achieved over the duration of a session. For example, where the target power level is reduced from 20-21W in the first period to around 15W in the second period, in some examples an energy saving of around 5-10% may be achieved due to reduced energy losses in the circuit 600 when operating at lower power. In one example, over the course of a typical session of around 260s in length, maintaining the target power at around 20W for the full duration of the session may result in energy usage of around 1000J. However, reducing the target power to around 15W upon the first zone 132a first reaching its set temperature and maintaining the target power level at 15W for the remainder of a session of substantially the same length may result in an energy usage of between 900 and 950J. In examples, almost all of the power used by the device is due to energy supplied to heat the susceptor 132. The power usage of electrical components other than the heating circuitry, e.g. LED indicators and the microcontroller, may be less than around 0.1W and in some examples may be less than around 0.01W.

[0186] Certain methods described herein may be implemented by way of non-transitory computer program code that is storable on a non-transitory storage medium. For example, in certain examples, the controller 1001 may comprise a non-transitory computer readable storage medium comprising a set of computer-readable instructions stored thereon and a processor to perform a method described herein when executed by the controller 1001. The controller 1001 may comprise one or more processors. For example, in some examples, as described above, the controller 1001 is a programmable micro-processing unit. The controller 1001 may comprise a storage medium comprising a set of machine readable instructions, e.g. in the form of computer code, which when executed by the controller 1001 cause a method described herein to be performed.

[0187] It should be noted that although a circuit com-

prising two inductor coils has been described above, aspects described above, such as for controlling power supplied in an inductive heating circuit may be applied to circuitry with a different number of coils, such as one or more than two coils.

Claims

1. An aerosol provision device (100) comprising:

a plurality of electrical components;
a heating assembly comprising a heater component for heating aerosol generating material;
and
a battery (118) to power the plurality of electrical components and the heating assembly;
wherein the plurality of electrical components comprises a controller (1001);

characterised in that:

the heating assembly comprises at least one coil (124, 126) configured to generate, in use, a varying magnetic field for penetrating and inductively heating the heater component, the heater component comprising a susceptor (132), the heating assembly further comprising an insulating member (128) which at least partially surrounds the susceptor; and
in use, the power consumption of the plurality of electrical components is less than 0.25W, wherein the plurality of electrical components comprises a plurality of LEDs and wherein each LED has a power consumption of less than 10mW at maximum intensity;
wherein in use, an outer surface of the device (100) remains below 48°C.

2. An aerosol provision device according to claim 1, wherein, in use, the power consumption of the plurality of electrical components is less than 0.1W.

3. An aerosol provision device according to claim 2, wherein the power consumption of the plurality of electrical components is less than 50mW.

4. An aerosol provision device according to claim 3, wherein the power consumption of the plurality of electrical components is less than 40mW.

5. An aerosol provision device according to any preceding claim, wherein, when the controller (1001) is active, the power consumption of the controller is between 10mW and 20mW, and when the controller is inactive, the power consumption of the plurality of electrical components is less than 0.5mW.

6. An aerosol provision device according to any preceding claim, wherein the controller (1001) comprises a microprocessor.
7. An aerosol provision device according to any preceding claim, wherein the plurality of electrical components further include a WiFi interface and/or a Bluetooth interface and/or an NFC interface. 5
8. An aerosol provision device according to any preceding claim, wherein, in use, the power consumption of the heating assembly is between 15W and 25W. 10
9. An aerosol provision device according to any preceding claim, wherein the battery (118) has a battery capacity of between 30000J and 35000J. 15
10. An aerosol provision device according to any preceding claim, wherein the heating assembly is configured to operate for a period of 3 minutes to 5 minutes, and is configured to consume between 1000J and 1400J during the period. 20
11. An aerosol provision device according to any preceding claim, wherein the heater assembly comprises a first coil (124) and a second coil (136) configured to heat the heater component. 25
12. An aerosol provision system comprising: 30
 - an aerosol provision device (100) according to any preceding claim; and
 - an article (110) comprising aerosol generating material. 35

Patentansprüche

1. Aerosolbereitstellungsvorrichtung (100), umfassend: 40
 - eine Vielzahl von elektrischen Komponenten;
 - eine Heizanordnung, die eine Heizkomponente zum Erhitzen von Aerosol erzeugendem Material umfasst; und 45
 - eine Batterie (118), um die Vielzahl von elektrischen Komponenten und die Heizanordnung mit Strom zu versorgen;
 - wobei die Vielzahl von elektrischen Komponenten eine Steuereinheit (1001) umfasst; **dadurch gekennzeichnet, dass:** 50
 - die Heizanordnung mindestens eine Spule (124, 126) umfasst, die konfiguriert ist, um im Betrieb ein variierendes Magnetfeld zum Durchdringen und induktiven Erhitzen der Heizkomponente zu erzeugen, wobei die 55

Heizkomponente einen Suszeptor (132) umfasst, wobei die Heizanordnung weiter ein Isolierelement (128) umfasst, das den Suszeptor zumindest teilweise umgibt; und der Stromverbrauch der Vielzahl von elektrischen Komponenten im Betrieb geringer als 0,25 W ist, wobei die Vielzahl von elektrischen Komponenten eine Vielzahl von LEDs umfasst und wobei jede LED bei maximaler Intensität einen Stromverbrauch von weniger als 10 mW aufweist;

wobei im Betrieb eine Außenoberfläche der Vorrichtung (100) unter 48 °C bleibt.

2. Aerosolbereitstellungsvorrichtung nach Anspruch 1, wobei der Stromverbrauch der Vielzahl von elektrischen Komponenten im Betrieb geringer als 0,1 W ist.
3. Aerosolbereitstellungsvorrichtung nach Anspruch 2, wobei der Stromverbrauch der Vielzahl von elektrischen Komponenten geringer als 50 mW ist.
4. Aerosolbereitstellungsvorrichtung nach Anspruch 3, wobei der Stromverbrauch der Vielzahl von elektrischen Komponenten geringer als 40 mW ist.
5. Aerosolbereitstellungsvorrichtung nach einem vorstehenden Anspruch, wobei der Stromverbrauch der Steuereinheit, wenn die Steuereinheit (1001) aktiv ist, zwischen 10 mW und 20 mW liegt, und der Stromverbrauch der Vielzahl von elektrischen Komponenten, wenn die Steuereinheit inaktiv ist, geringer als 0,5 mW ist.
6. Aerosolbereitstellungsvorrichtung nach einem vorstehenden Anspruch, wobei die Steuereinheit (1001) einen Mikroprozessor umfasst.
7. Aerosolbereitstellungsvorrichtung nach einem vorstehenden Anspruch, wobei die Vielzahl von elektrischen Komponenten weiter eine WiFi-Schnittstelle und/oder eine Bluetooth-Schnittstelle und/oder eine NFC-Schnittstelle beinhaltet.
8. Aerosolbereitstellungsvorrichtung nach einem vorstehenden Anspruch, wobei der Stromverbrauch der Heizanordnung im Betrieb zwischen 15 W und 25 W liegt.
9. Aerosolbereitstellungsvorrichtung nach einem vorstehenden Anspruch, wobei die Batterie (118) eine Batteriekapazität zwischen 30000 J und 35000 J aufweist.
10. Aerosolbereitstellungsvorrichtung nach einem vorstehenden Anspruch, wobei die Heizanordnung

konfiguriert ist, um für einen Zeitraum von 3 Minuten bis 5 Minuten in Betrieb zu sein, und konfiguriert ist, um während des Zeitraums zwischen 1000 J und 1400 J zu verbrauchen.

11. Aerosolbereitstellungsvorrichtung nach einem vorstehenden Anspruch, wobei die Heizanordnung eine erste Spule (124) und eine zweite Spule (136) umfasst, die konfiguriert sind, um die Heizkomponente zu erhitzen.

12. Aerosolbereitstellungssystem umfassend:

eine Aerosolbereitstellungsvorrichtung (100) nach einem vorstehenden Anspruch; und einen Artikel (110), der Aerosol erzeugendes Material umfasst.

Revendications

1. Dispositif de fourniture d'aérosol (100) comprenant :

une pluralité de composants électriques ;
un ensemble de chauffage comprenant un composant chauffant pour chauffer un matériau de génération d'aérosol ; et
une batterie (118) pour alimenter la pluralité de composants électriques et l'ensemble de chauffage ;
dans lequel la pluralité de composants électriques comprennent un dispositif de commande (1001) ; **caractérisé en ce que** :

l'ensemble de chauffage comprend au moins une bobine (124, 126) configurée pour générer, lors de l'utilisation, un champ magnétique variable pour pénétrer et chauffer par induction le composant chauffant, le composant chauffant comprenant un suscepteur (132), l'ensemble de chauffage comprenant en outre un élément isolant (128) qui entoure au moins partiellement le suscepteur ; et
lors de l'utilisation, la consommation d'énergie de la pluralité de composants électriques est inférieure à 0,25 W, dans lequel la pluralité de composants électriques comprennent une pluralité de DEL et chaque DEL présente une consommation d'énergie inférieure à 10 mW à intensité maximale ;

dans lequel, lors de l'utilisation, une surface extérieure du dispositif (100) reste au-dessous de 48 °C.

2. Dispositif de fourniture d'aérosol selon la revendica-

tion 1, dans lequel, lors de l'utilisation, la consommation d'énergie de la pluralité de composants électriques est inférieure à 0,1 W.

3. Dispositif de fourniture d'aérosol selon la revendication 2, dans lequel la consommation d'énergie de la pluralité de composants électriques est inférieure à 50 mW.

4. Dispositif de fourniture d'aérosol selon la revendication 3, dans lequel la consommation d'énergie de la pluralité de composants électriques est inférieure à 40 mW.

5. Dispositif de fourniture d'aérosol selon une quelconque revendication précédente, dans lequel, lorsque le dispositif de commande (1001) est actif, la consommation d'énergie du dispositif de commande est comprise entre 10 mW et 20 mW, et lorsque le dispositif de commande est inactif, la consommation d'énergie de la pluralité de composants électriques est inférieure à 0,5 mW.

6. Dispositif de fourniture d'aérosol selon une quelconque revendication précédente, dans lequel le dispositif de commande (1001) comprend un microprocesseur.

7. Dispositif de fourniture d'aérosol selon une quelconque revendication précédente, dans lequel la pluralité de composants électriques incluent en outre une interface WiFi et/ou une interface Bluetooth et/ou une interface NFC.

8. Dispositif de fourniture d'aérosol selon une quelconque revendication précédente, dans lequel, lors de l'utilisation, la consommation d'énergie de l'ensemble de chauffage est comprise entre 15 W et 25 W.

9. Dispositif de fourniture d'aérosol selon une quelconque revendication précédente, dans lequel la batterie (118) présente une capacité de batterie comprise entre 30 000 J et 35 000 J.

10. Dispositif de fourniture d'aérosol selon une quelconque revendication précédente, dans lequel l'ensemble de chauffage est configuré pour fonctionner pendant une période de 3 minutes à 5 minutes et est configuré pour consommer entre 1000 J et 1400 J pendant la période.

11. Dispositif de fourniture d'aérosol selon une quelconque revendication précédente, dans lequel l'ensemble de chauffage comprend une première bobine (124) et une seconde bobine (136) configurées pour chauffer le composant de chauffage.

12. Système de fourniture d'aérosol comprenant :

un dispositif de fourniture d'aérosol (100) selon
une quelconque revendication précédente ; et
un article (110) comprenant un matériau de 5
génération d'aérosol.

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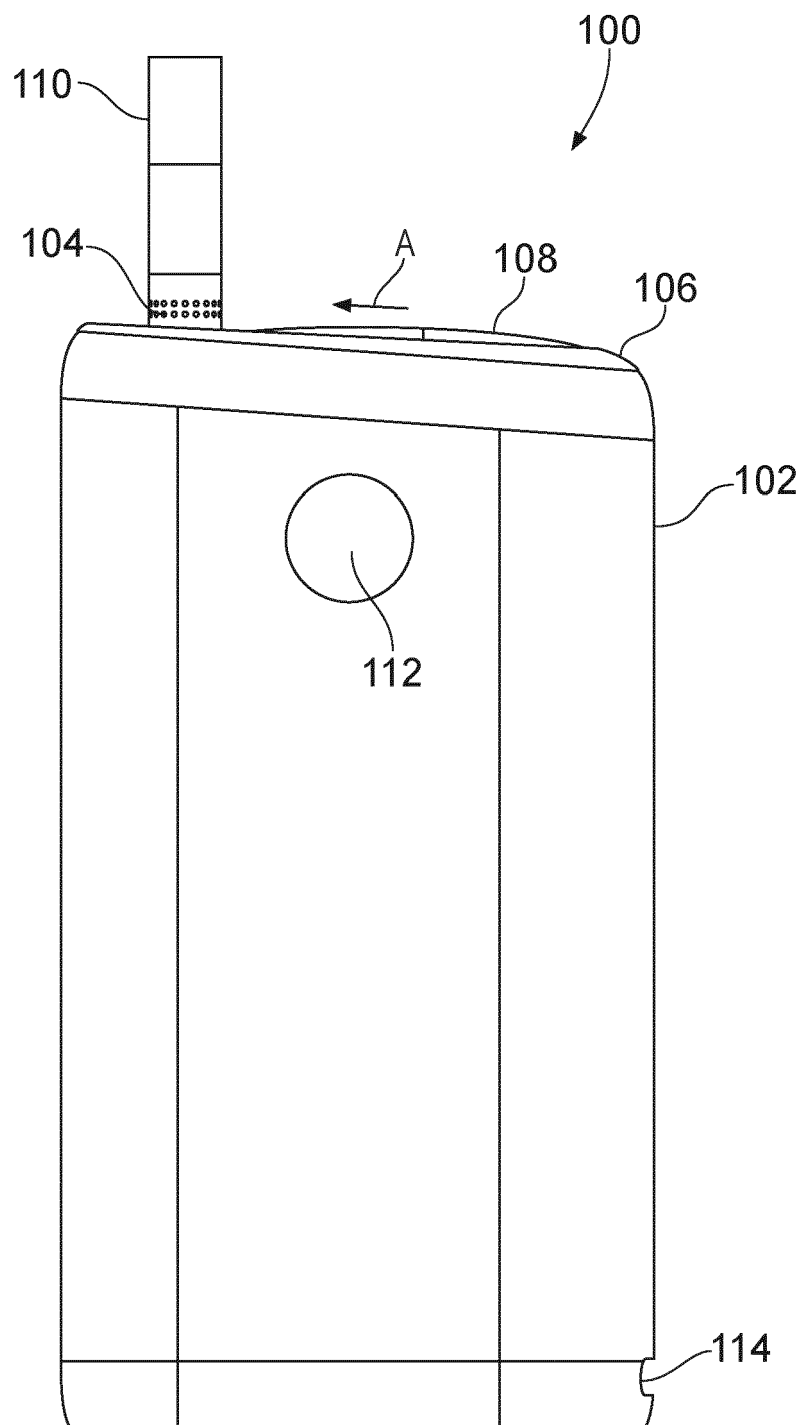


FIG. 1

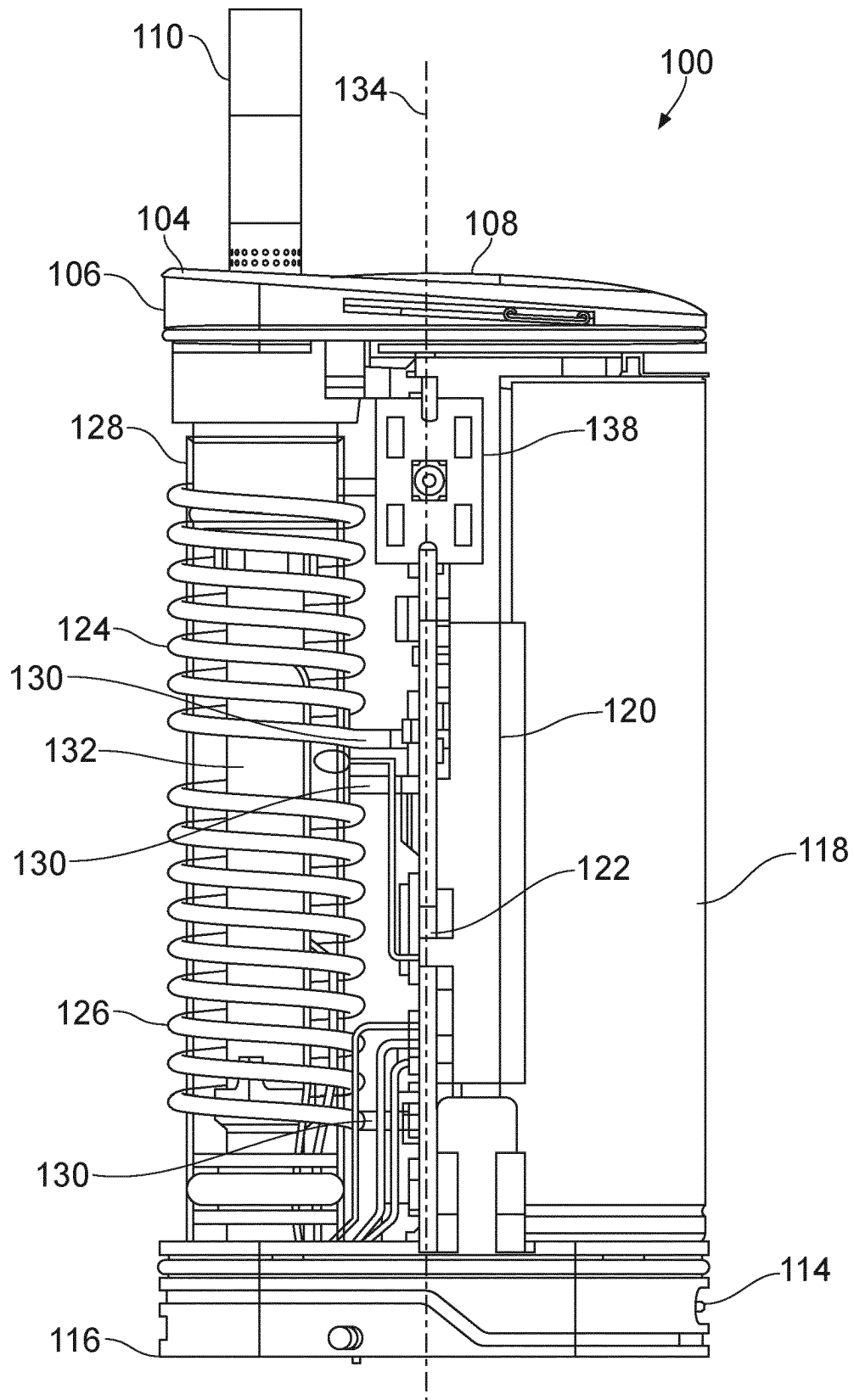


FIG. 2

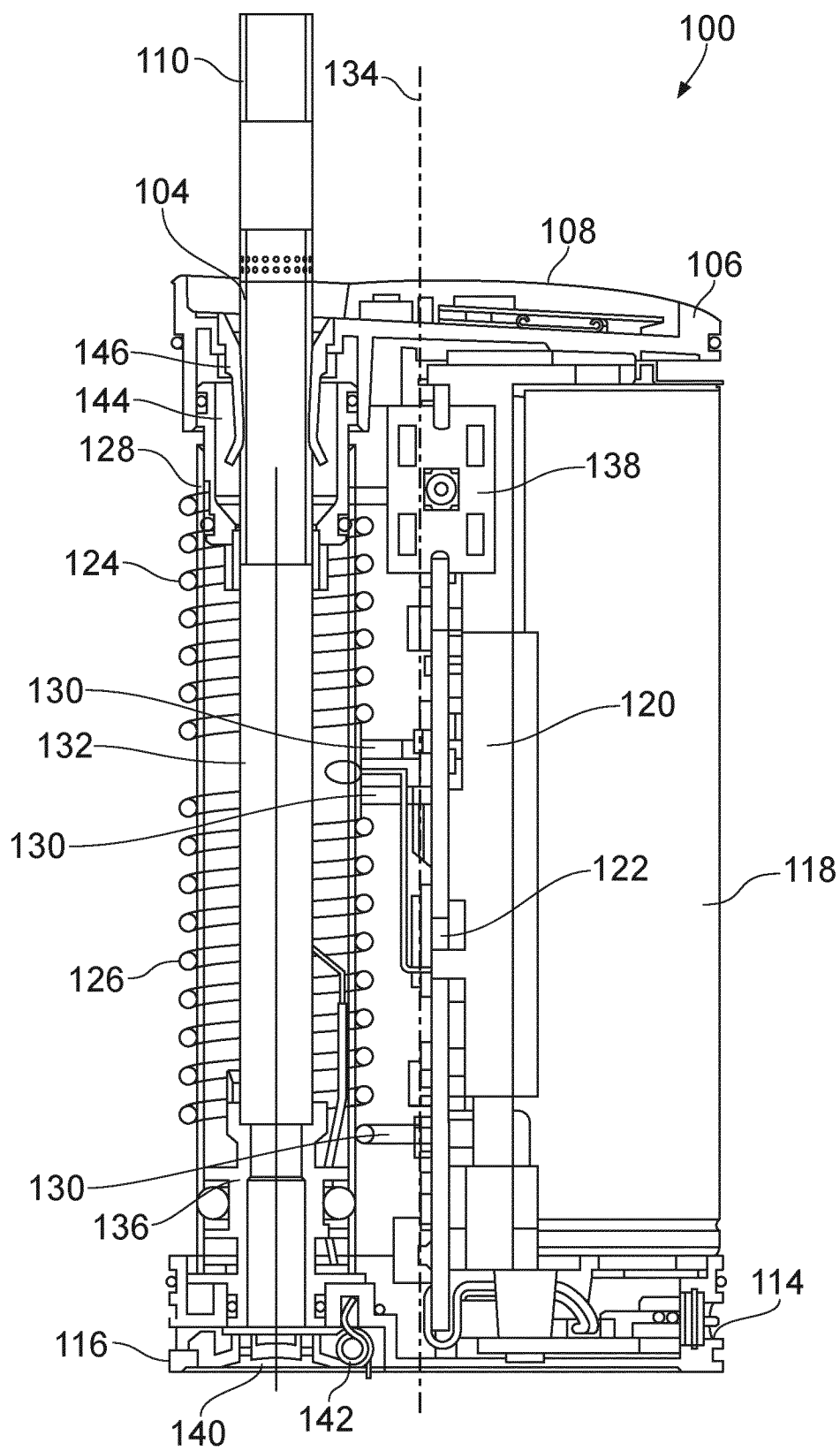


FIG. 3

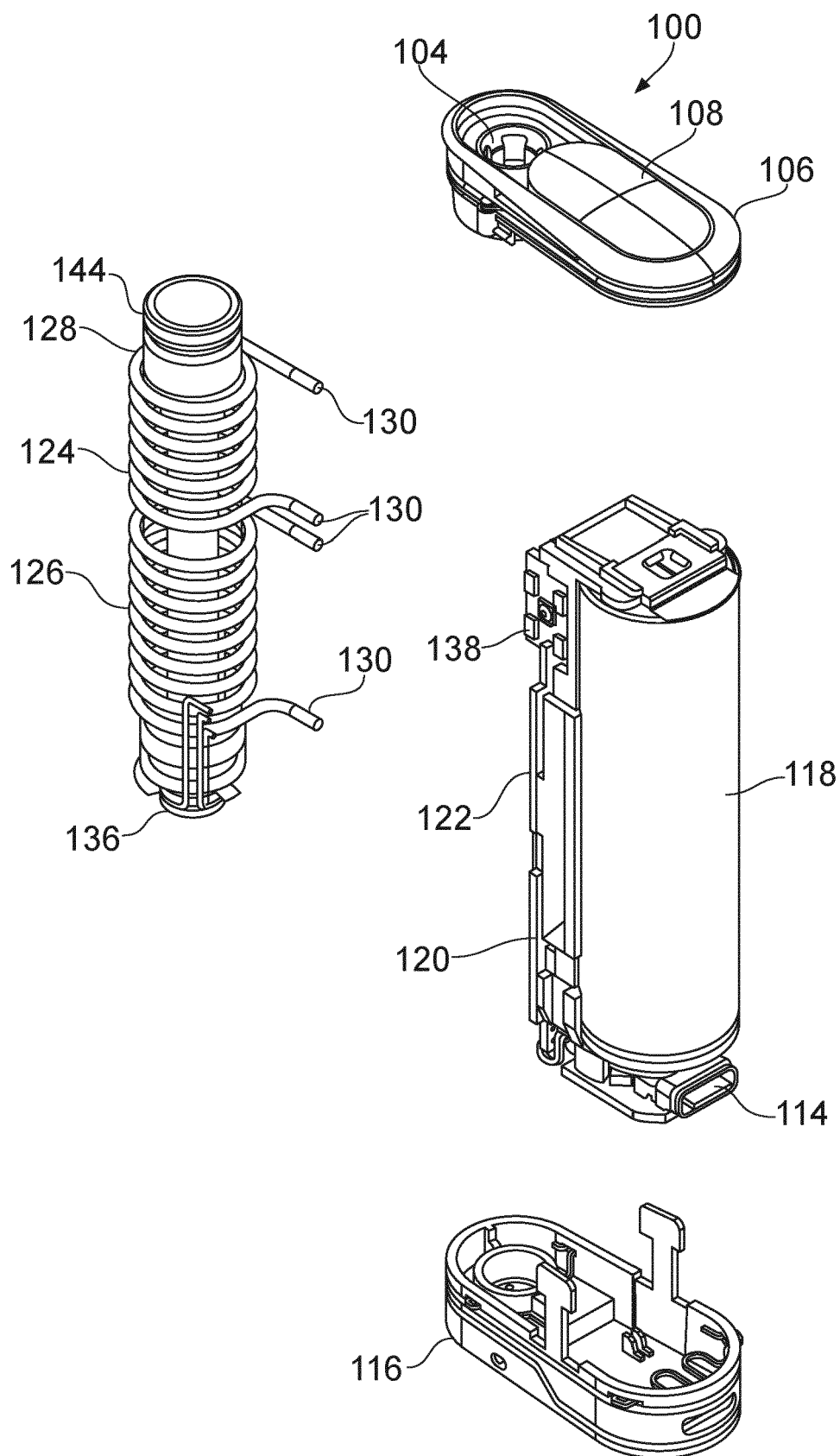


FIG. 4

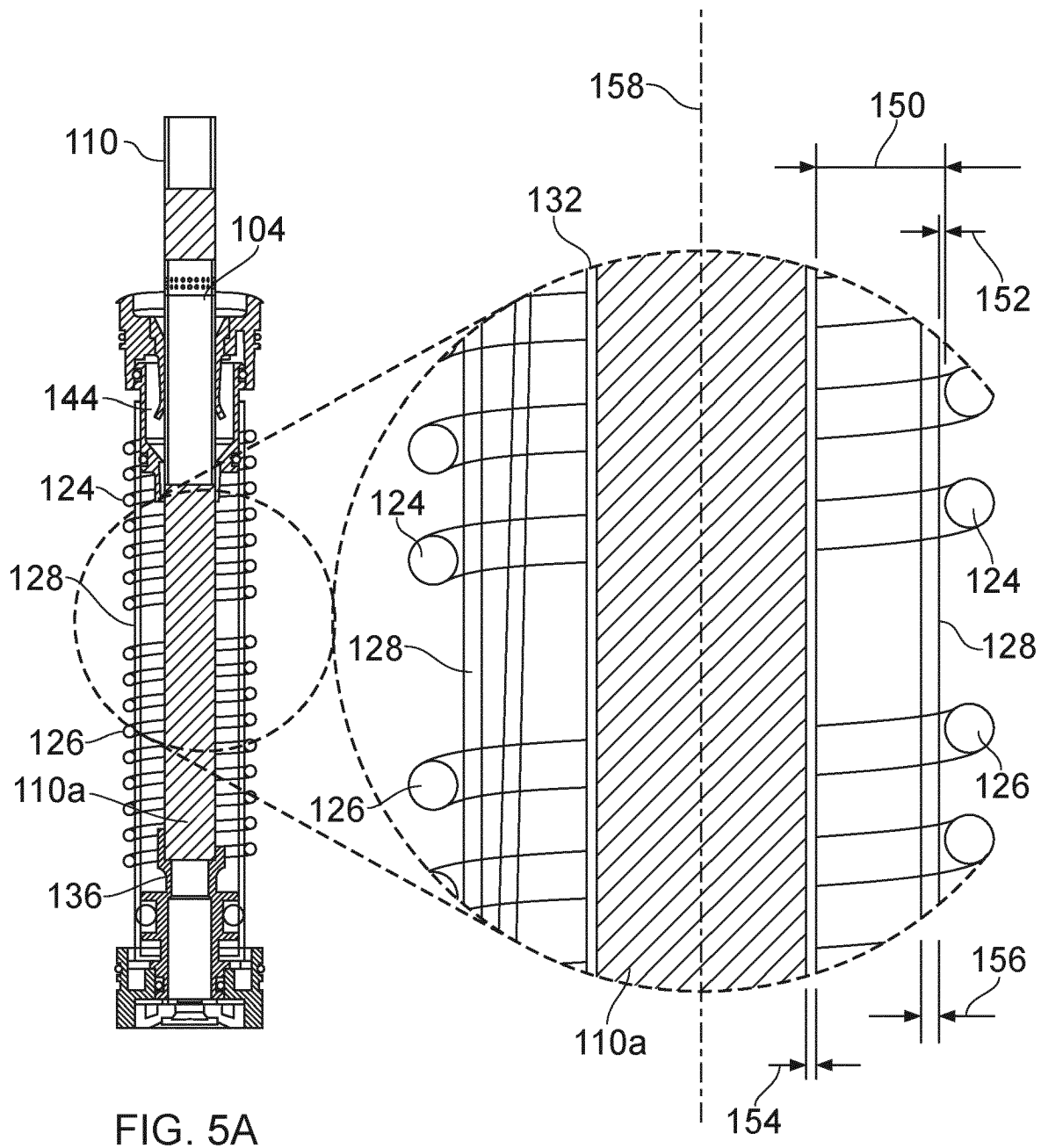


FIG. 5A

FIG. 5B

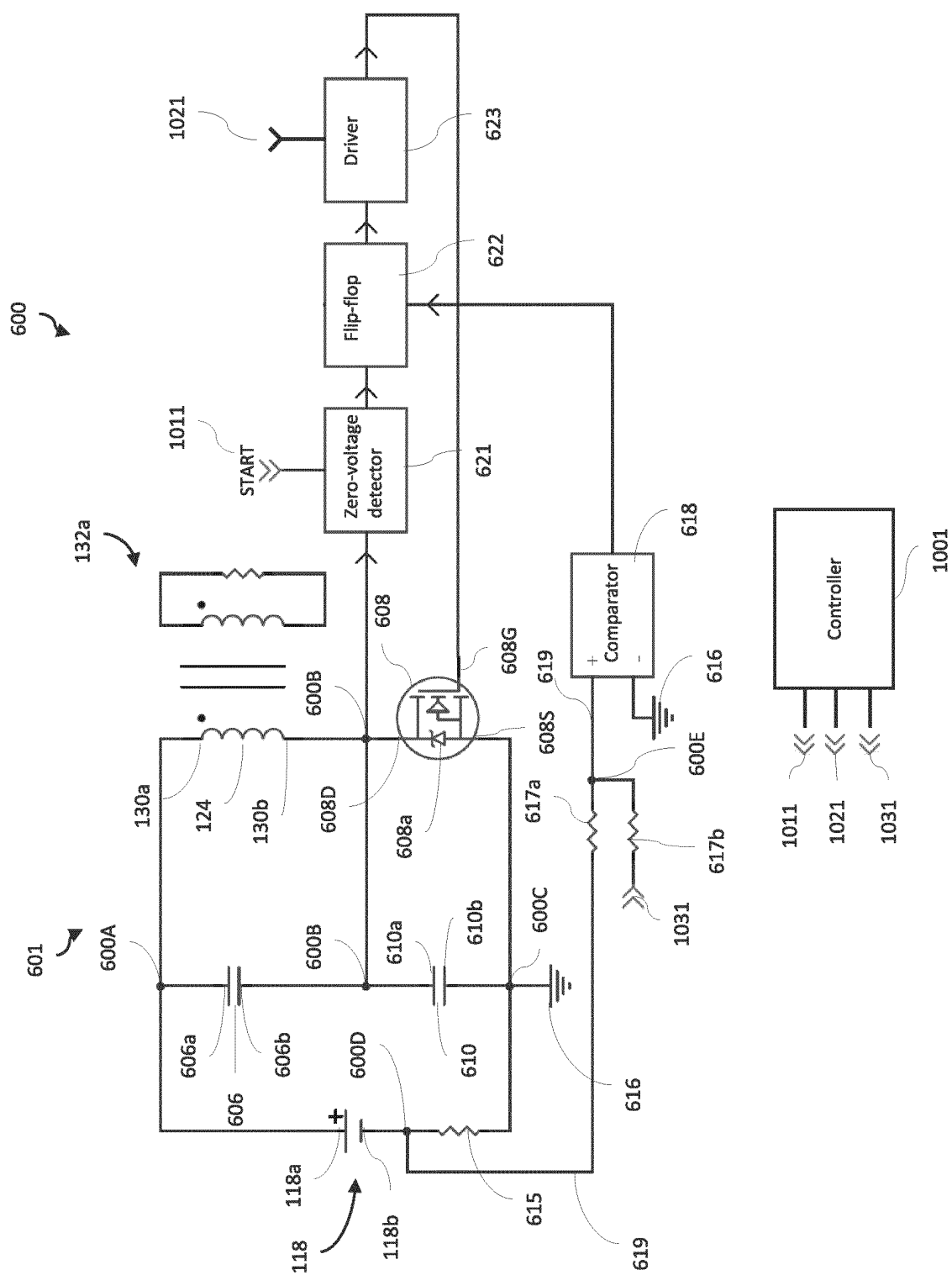


Fig. 6

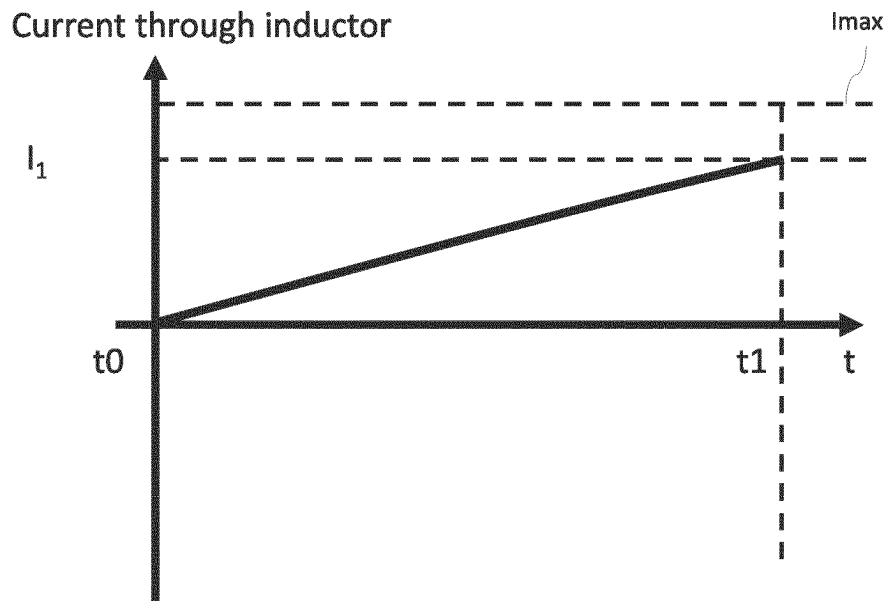


Fig. 7A

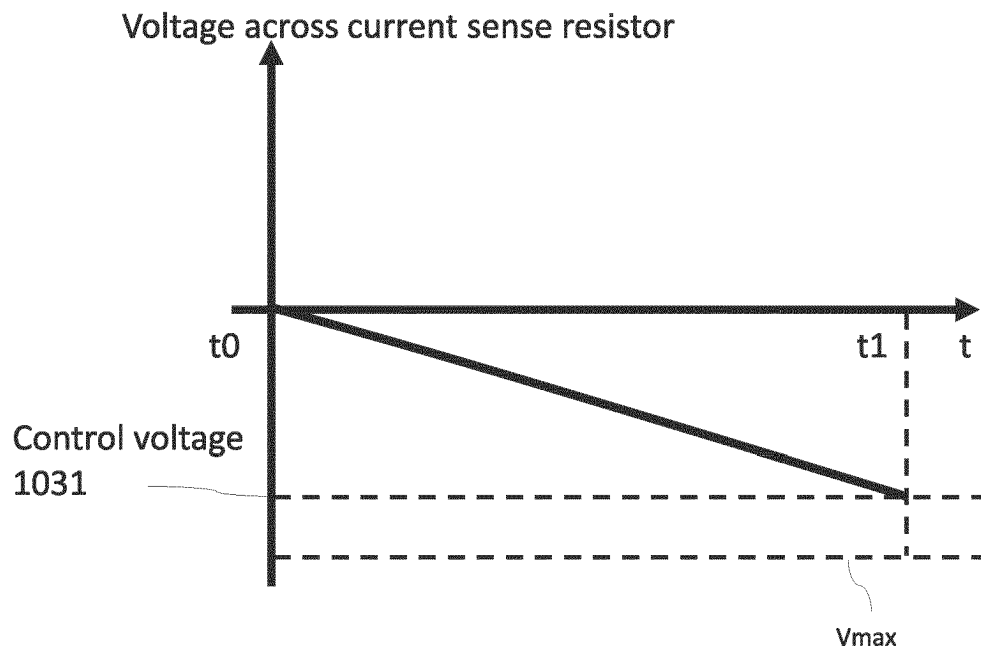


Fig. 7B

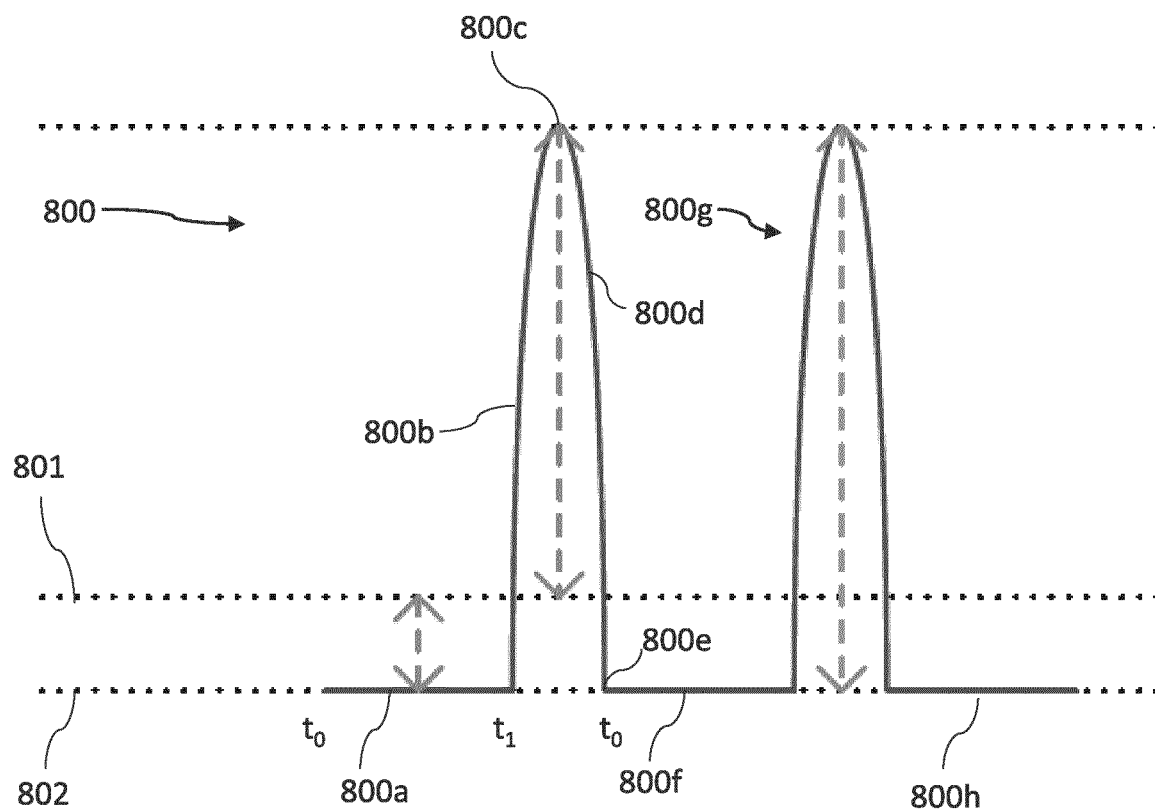


Fig. 8

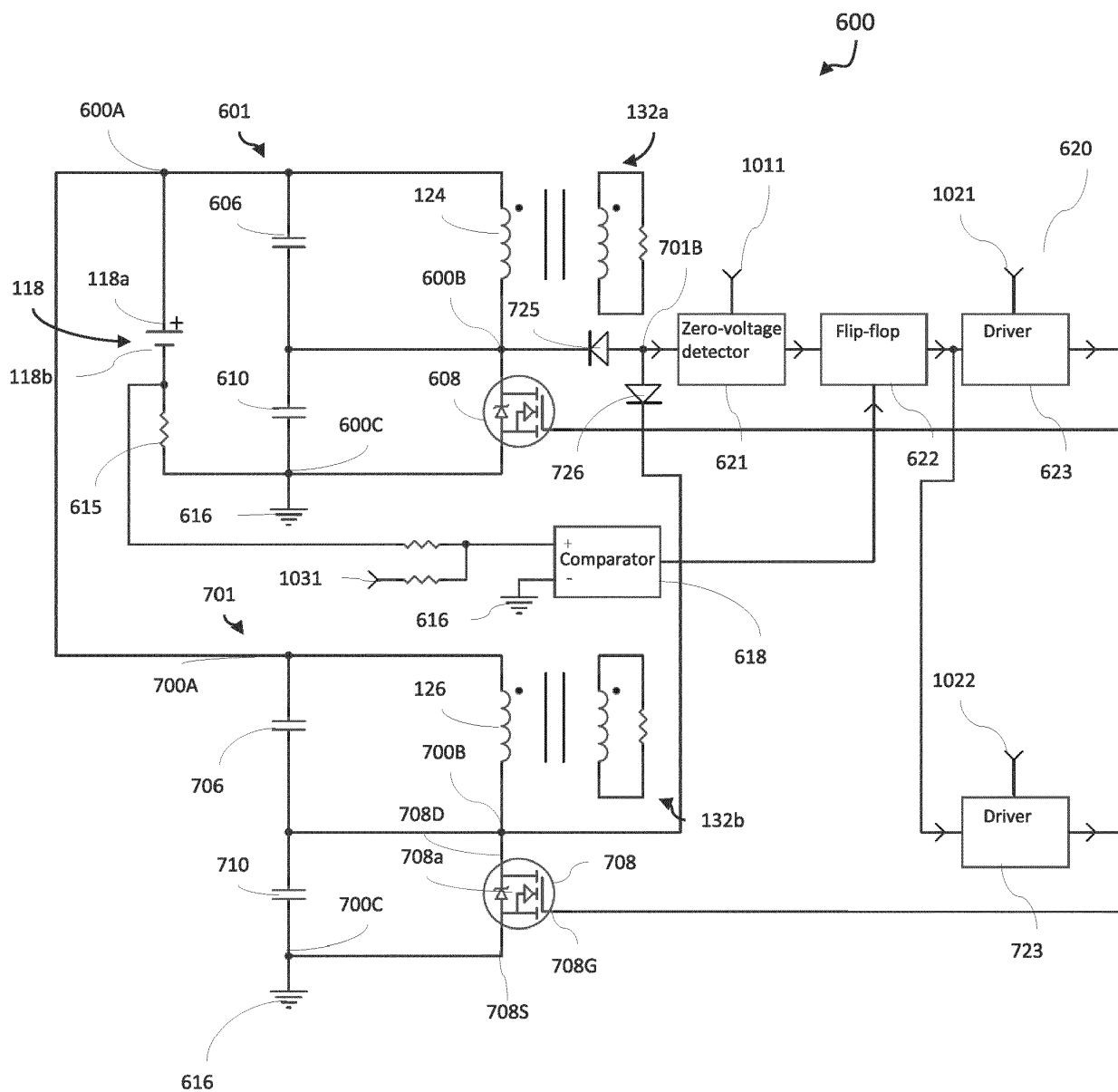
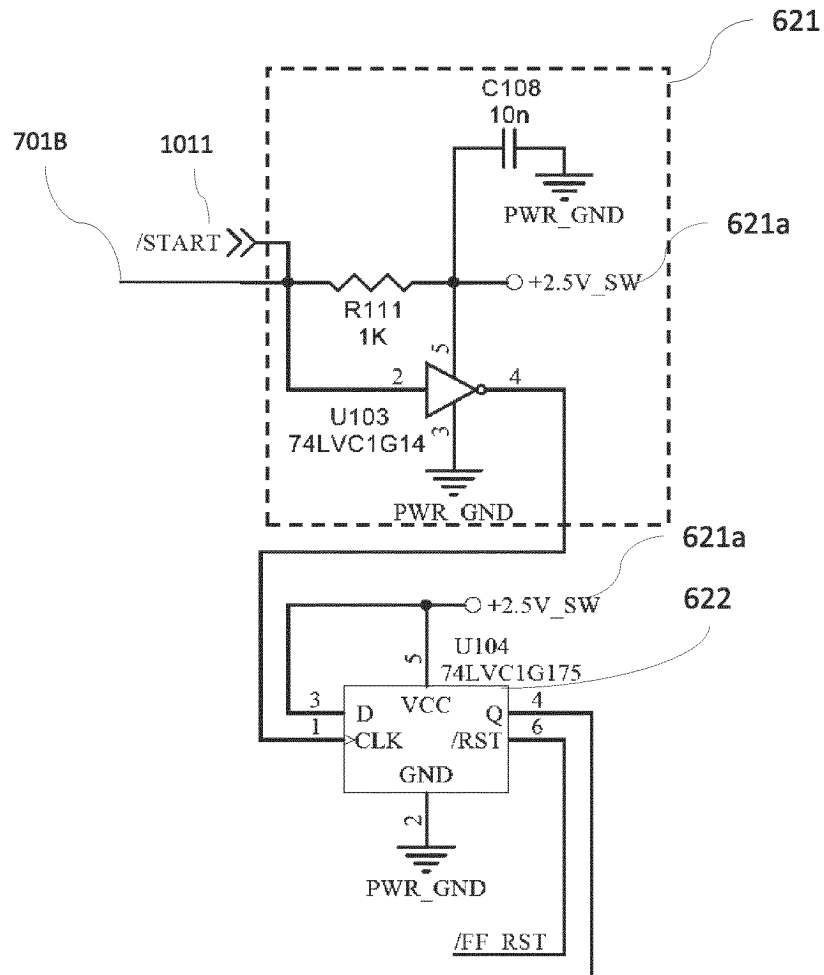
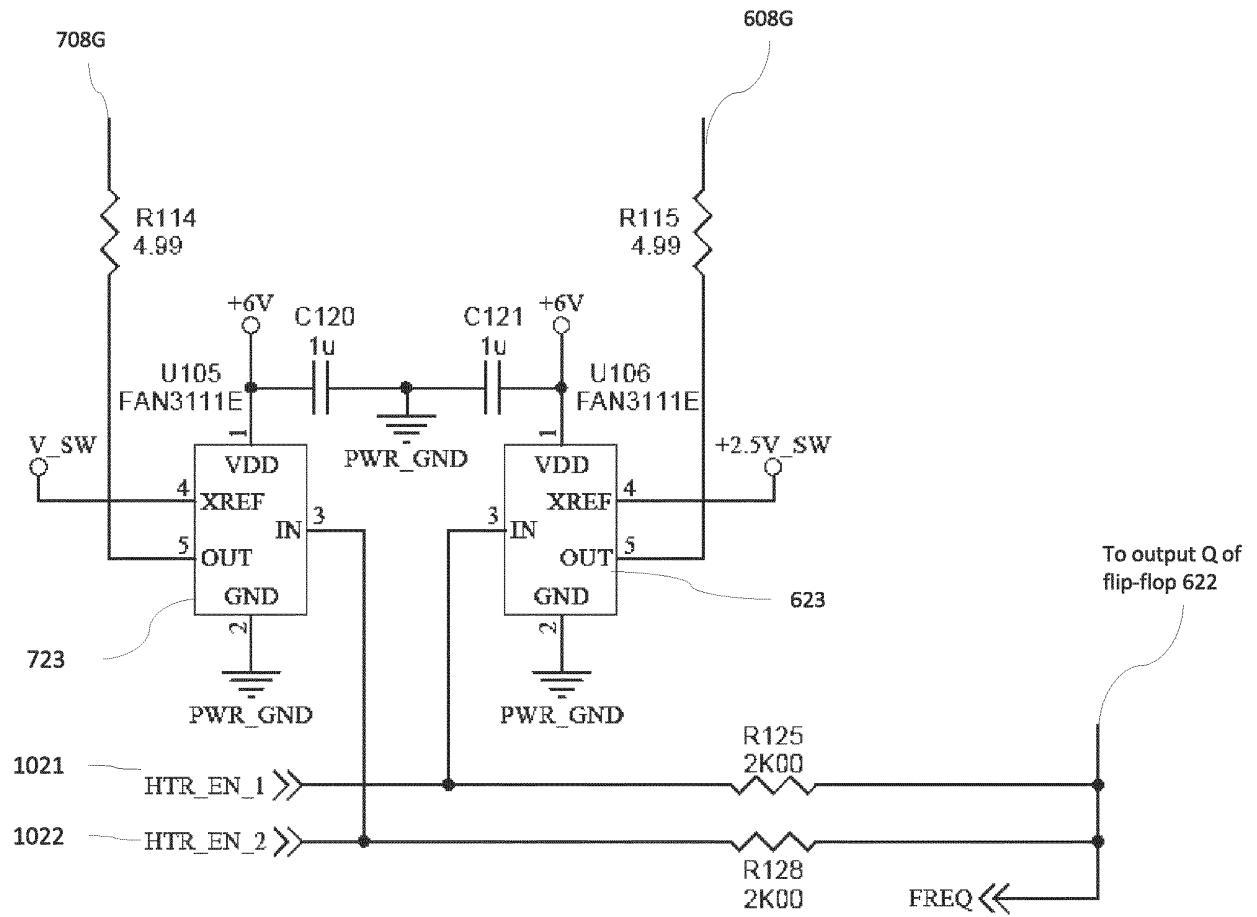


Fig. 9

**Fig. 10**

**Fig. 11**

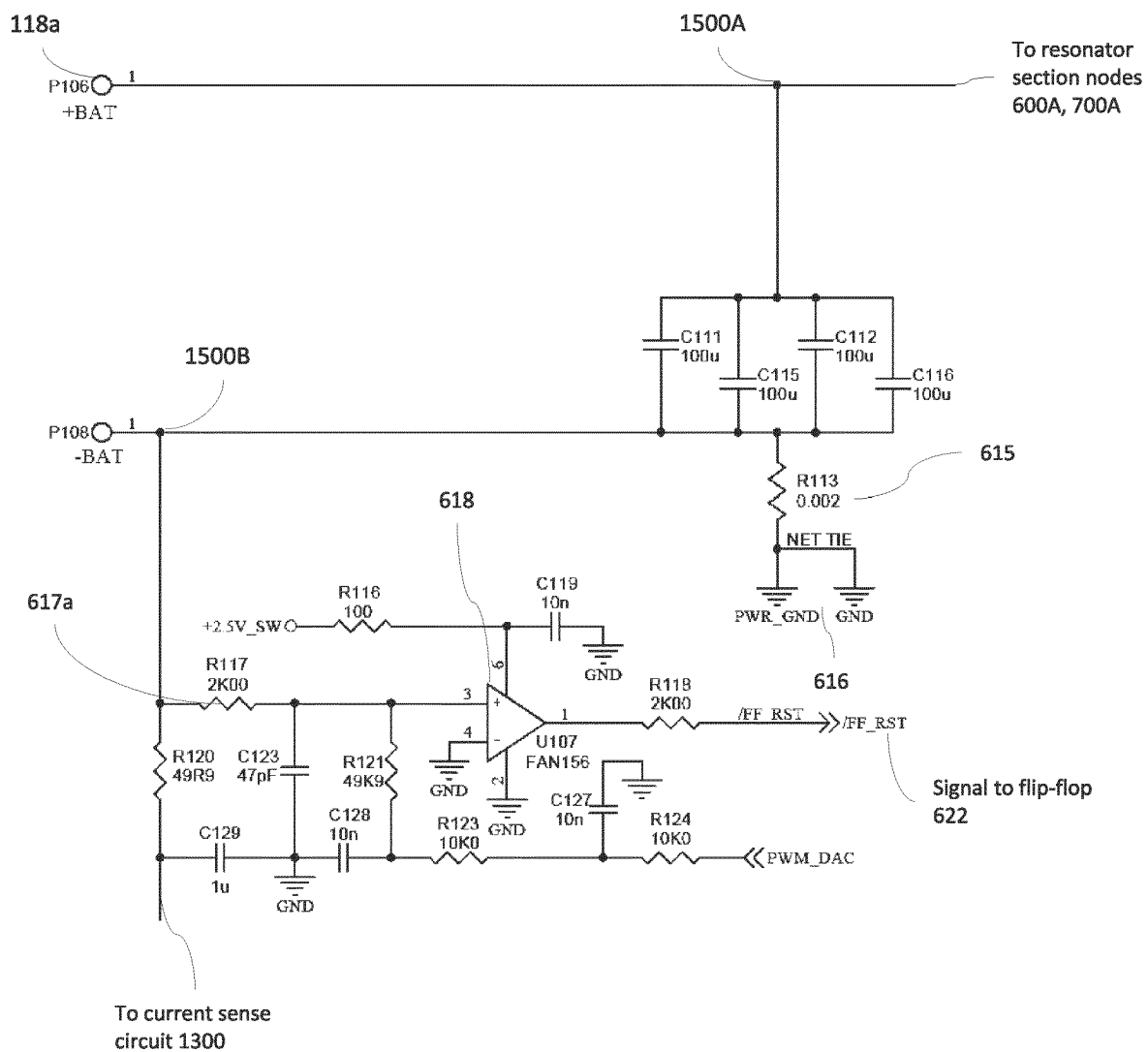
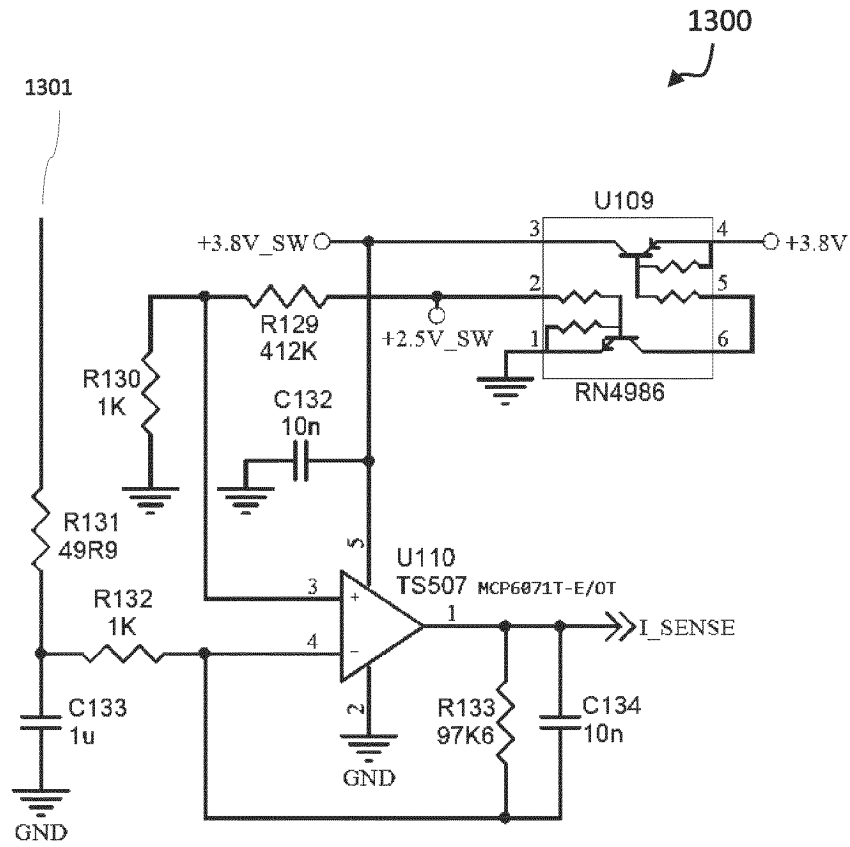
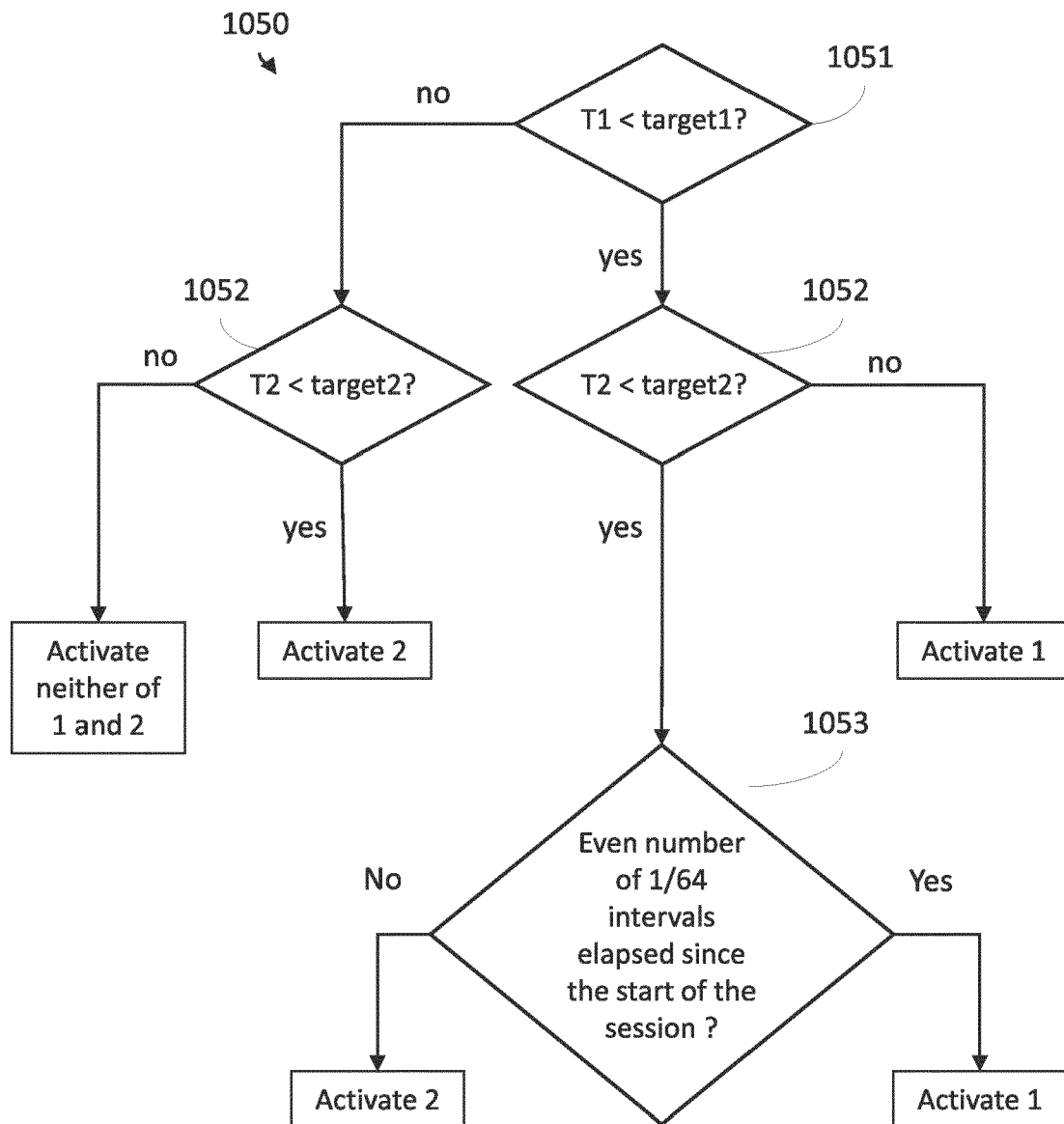


Fig. 12

**Fig. 13**

**Fig. 14**

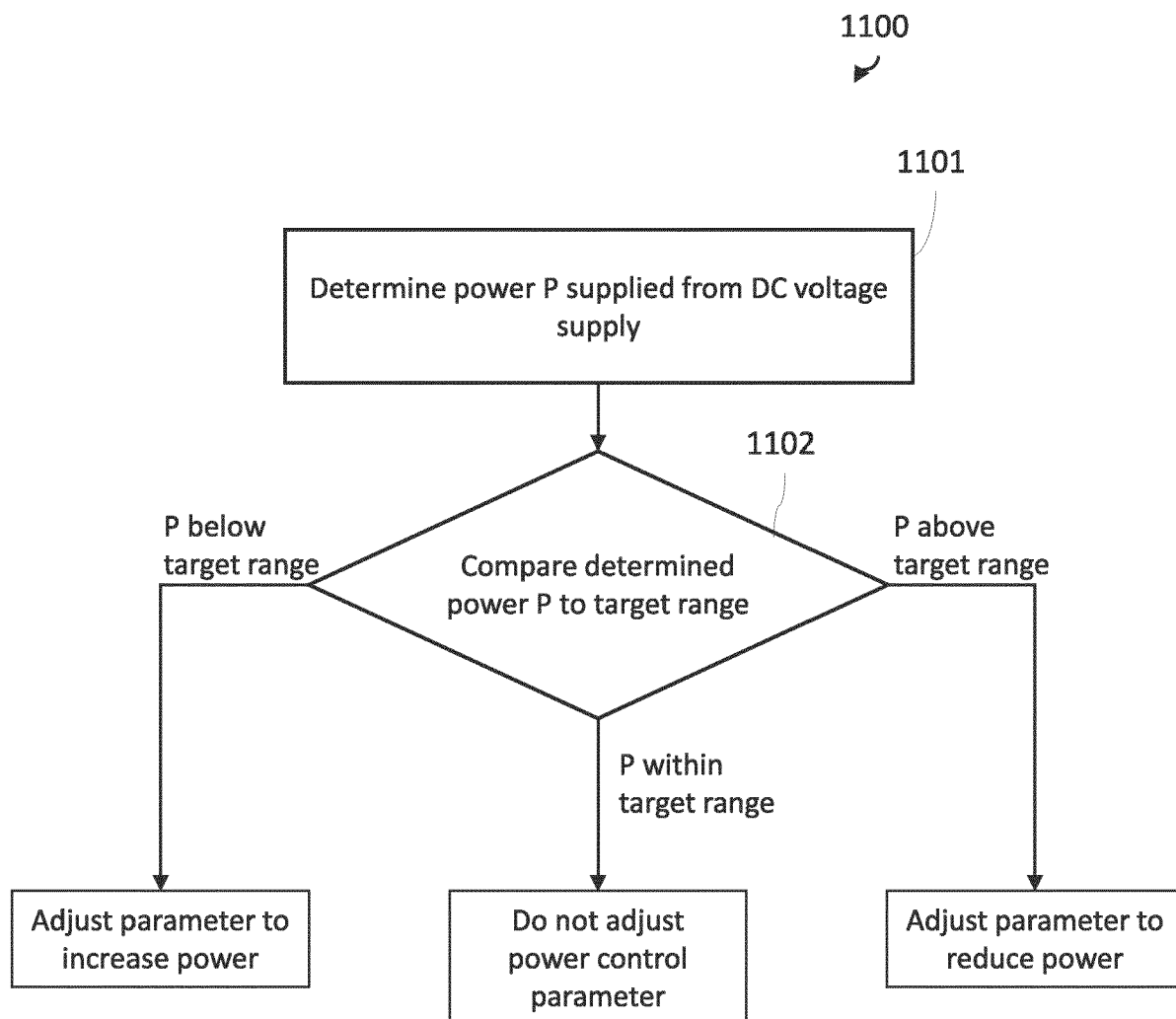


Fig. 15

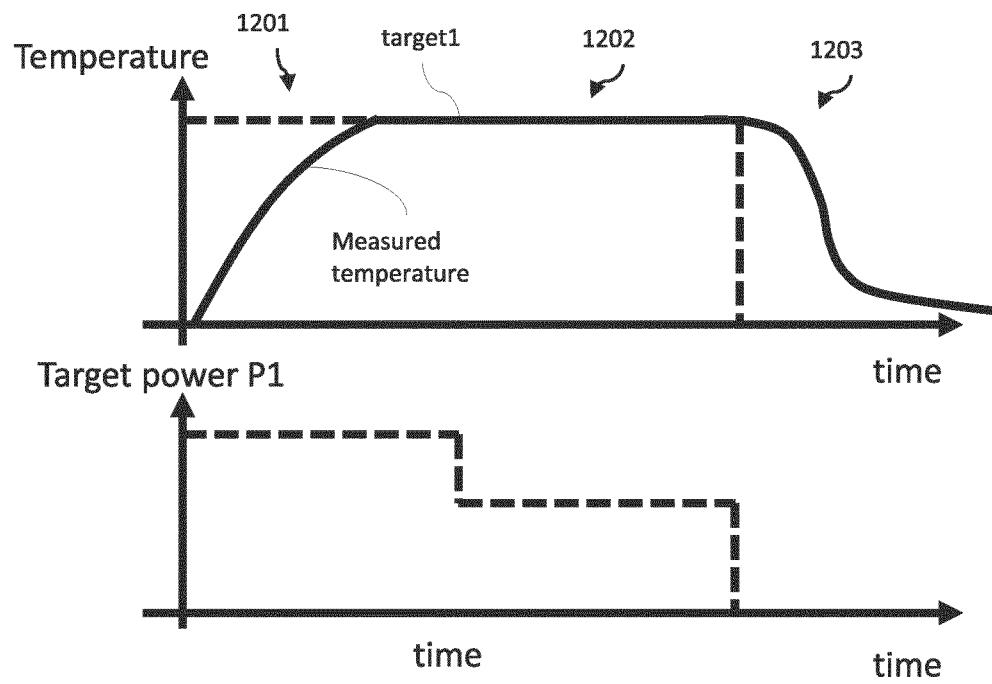


Fig. 16

REFERENCES CITED IN THE DESCRIPTION

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